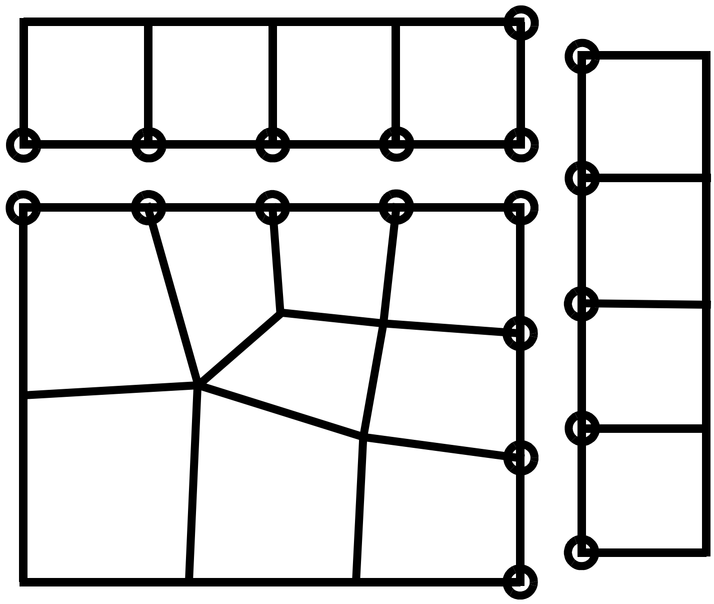
SESAM
USER MANUAL

Presel



Preprocessor for Assembling Superelements

DET NORSKE VERITAS

SESAM
User Manual

Presel

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October 1st, 2004

Valid from program version 7.3

Developed and marketed by
DET NORSKE VERITAS

DNV Software Report No.: 82-6113 / Revision 8, October 1st, 2004

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1 INTRODUCTION

1.1 Presel — Preprocessor for Assembling Superelements

To use Presel you should know some terms. These are highlighted by *italic text* first time they appear.

Presel is SESAM's preprocessor for assembling superelements. A *superelement* is basically a finite element (FE) model of a part of the complete structure. The SESAM preprocessors Preframe (for frame modelling) and Prefem (for general FE modelling) are used for creating *first level superelements*, i.e. part models comprised of finite elements like beams, shells, etc. adjoined in nodes.

Presel is used to put these parts together to form *superelement assemblies*. First level superelements are typically assembled to form *second level superelement assemblies,* these are in turn assembled to form *third level superelement assemblies,* and so on until the complete model — the *top level superelement assembly* — is formed. Note that a superelement assembly is referred to as a superelement when itself is included in an assembly. Superelements on levels higher than 1, i.e. superelements created by Presel rather than by Preframe/Prefem, are often referred to as *higher level superelements.*

A *superelement hierarchy* showing the assembly process from bottom to top can be sketched as illustrated for the two examples in Figure 1.1.

An unlimited number of superelements can be included in a superelement assembly. Furthermore, there is no limit to the number of levels of a superelement hierarchy.

A superelement model may be used for linear structural analysis using Sestra, or hydrodynamic analysis (wave loading and motion) of frame structures using Wajac and of general structures using Wadam.

First level superelements created by SESAM's preprocessor for tubular joint modelling, Pretube, may also be assembled by Presel. The same goes for superelements created by any FE preprocessor as long as they are defined according to the SESAM Input Interface File format.

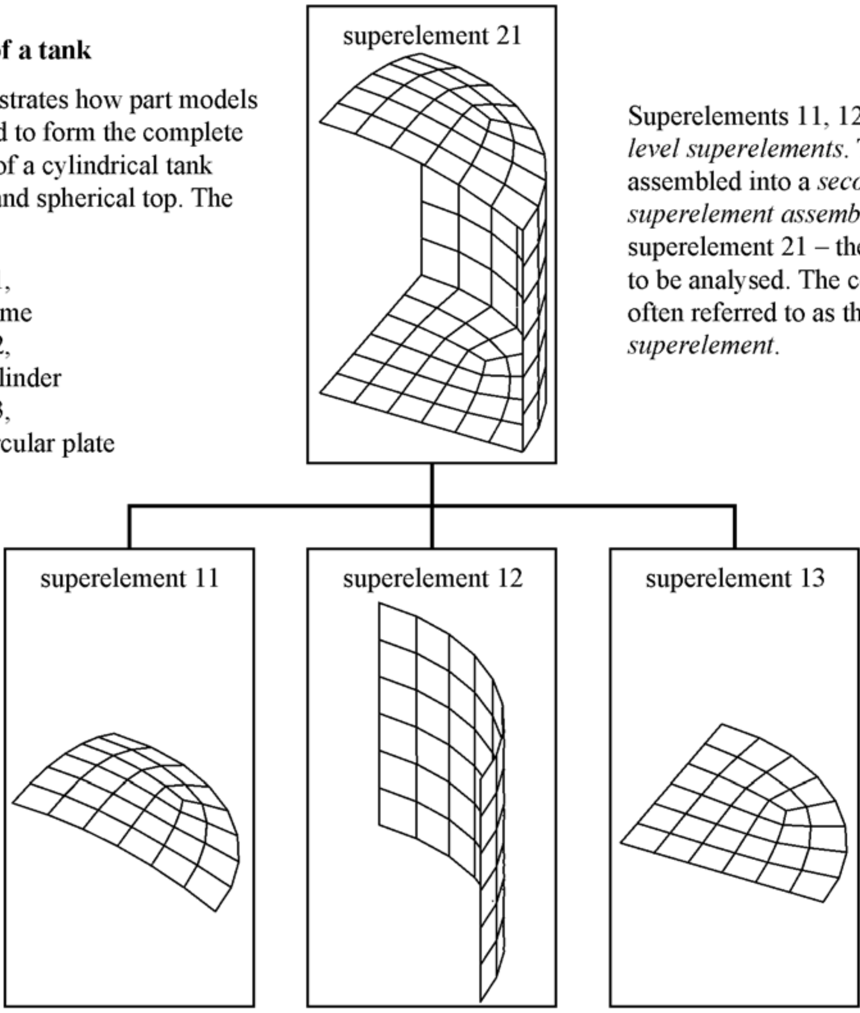
To fully appreciate the purpose and use of Presel an understanding of the mathematical foundation of the superelement technique is required; see Appendix B THEORY. Also a basic understanding of a first level superelement as modelled by e.g. Preframe and Prefem is required.

Example 1
Quarter model of a tank

This example illustrates how part models may be assembled to form the complete model: a quarter of a cylindrical tank with flat bottom and spherical top. The part models are:

- Superelement 11, a quarter of a dome
- Superelement 12, a quarter of a cylinder
- Superelement 13, a quarter of a circular plate

Superelements 11, 12 and 13 are *first level superelements*. They are assembled into a *second level superelement assembly* – superelement 21 – the complete model to be analysed. The complete model is often referred to as the *top level superelement*.



Example 2
Full model of a tank

The whole tank may be modelled by including superelement 21 four times (and rotating it 0°, 90°, 180° and 270°) to form a third level superelement 31.

The hierarchical structure of the superelement model is shown.

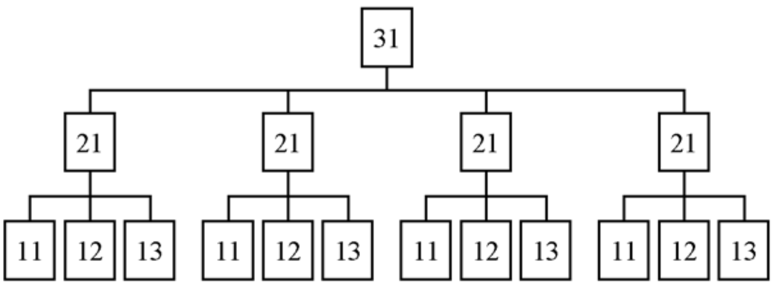


Figure 1.1 Illustration of superelement hierarchies

1.2 Presel in the SESAM System

SESAM is comprised of preprocessors, environmental analysis programs, structural analysis programs and postprocessors. An overview of SESAM is shown in Figure 1.2.

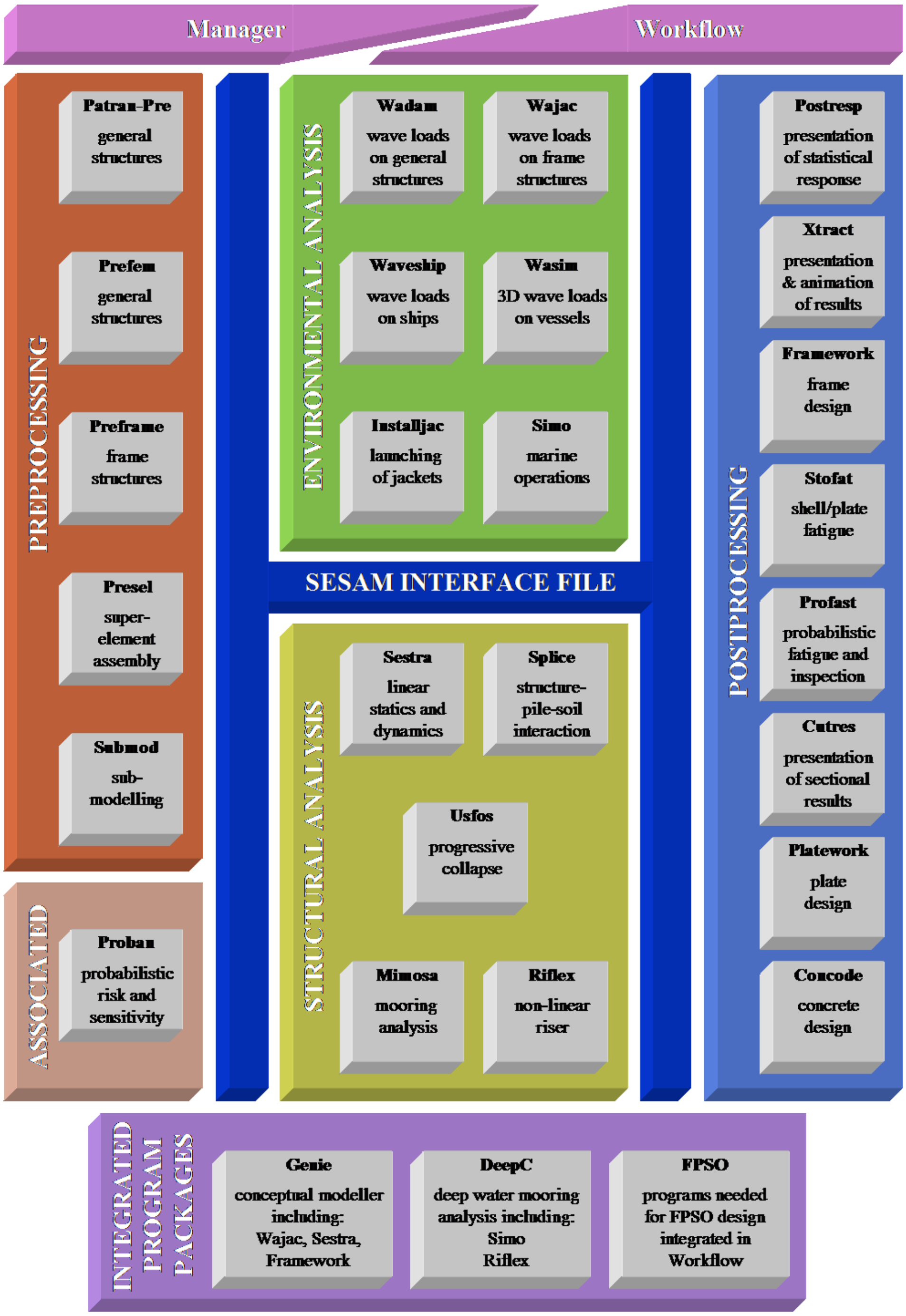


Figure 1.2 SESAM overview

1.3 How to read the Manual

If you are a new user then first read the introduction in Section 1.1. Continue with Section 2.1 (and skim through Section 2.2) to learn about basic features and principles of assembling superelements.

If you already have a basic understanding of SESAM and the superelement technique then proceed as follows:

- Read Section 3.1 to learn how to start Presel and use the graphical user interface.
- Read Section 3.2.1 to learn about the basic procedure of assembling superelements.
- Study the tutorial in assembling superelements of Section 3.2.2.
- Read Section 3.2.3, Section 3.2.4 and Section 3.2.5 to learn how to identify superelements and nodes. Note two important rules mentioned in Section 3.2.6.
- Read Section 3.3.1 and study the tutorial in combining loads in Section 3.3.2.
- Conclude by looking into Section 3.3.3, Section 3.5, Section 3.8 and Section 3.9.

Chapter 4 EXECUTION OF PRESEL contains more special information not intended for the new user using Manager to control his SESAM analysis. The chapter explains how to start Presel outside Manager and operate it in line-mode (not using the graphical user interface). The files used by Presel are also explained. Practical information is provided on how to operate Presel and manipulate its files in various ways. Built-in and hardware dependent requirements and limitations are also described.

Chapter 5 COMMAND DESCRIPTION explains in detail all commands of Presel. The commands and subcommands are sorted alphabetically.

Appendix A TUTORIAL EXAMPLES provides input (to Prefem) for creating the first level superelements used in the tutorials of Chapter 3 USER'S GUIDE TO PRESEL.

Appendix B THEORY explains the mathematical foundation of the superelement technique.

1.4 Status List

There exists for Presel as for all other SESAM programs a Status List providing additional information. This may be:

- Reasons for update (new version)
- New features
- Errors found and corrected
- Etc.

To look up information in the most updated version of the Status List go to the support page of our website, click the SESAM Status Lists link and log into this service. Contact us for log-in information.

2 FEATURES OF PRESEL

Presel is a program for assembling superelements (part models) to form the complete model to be analysed.

2.1 Basic Features and Principles

Presel reads the first level superelements from the Input Interface Files. These files are named T#.FEM where # is the superelement number, an identification of the superelement.

The first level superelements may be displayed and given names but not modified in any way. If a first level superelement need to be modified you have to revert to the preprocessor that created it, e.g. Prefem or Preframe. A first level superelement cannot be modified once it has been read into Presel.

Higher level superelements are created in Presel. A higher level superelement contains no nodes and elements until one or more superelements have been included into it. A higher level superelement is given contents by including first level superelements and/or previously created higher level superelements. There are no restrictions as to the number of superelements that may be included in an assembly. Superelements at any level may be included in the same assembly. The assembly will implicitly be assigned a superelement level equal to the highest level among its included superelements plus one. For example, if the highest level among the included superelements is three then the assembly will be a level four superelement.

Boundary conditions like supernodes and fixations as well as loads are defined for higher level superelements (assemblies). The loads will normally be combinations of loads previously defined for the included superelements but nodal forces may also be defined.

Once a higher level superelement is included in yet a higher level superelement it can no longer be modified in any way, for example by including more superelements or defining boundary conditions and loads.

The top (highest) level superelement is complete when the whole model to be analysed has been formed including all its loads and boundary conditions. There is no limit to at which level this top level is. The top level number is simply a result of the hierarchical assembling of superelements from bottom to top.

The final task of Presel is to produce (write) the Input Interface Files (T#.FEM, the T-files) for all higher level superelements that has been created.

2.2 Short Description of Commands

A short description of each main command in Presel is given below.

ASSEMBLY	creates a new higher level superelement or opens an old one. This is then the *current* superelement. The current superelement is displayed by the DISPLAY command and superelements may be included into it using the INCLUDE command.
BOUNDARY	defines boundary conditions for the current superelement.
CHANGE	changes loads, transformations and linear dependencies.
COORDINATE-SYSTEM	defines a coordinate system that can be referred to when defining boundary conditions and when selecting nodes (presently limited to cylindrical).
DEFINE	defines sets.
DISPLAY	displays superelements and contributions to load combinations.
HELP	provides information on the command syntax and how to get technical support. The command also launches the Status program providing access to the Status List of Presel.
INCLUDE	includes a superelement in the current higher level superelement assembly.
LABEL	annotates node symbols, node numbers etc. to the displayed superelement.
LINEAR-DEPENDENCY	makes one or more degrees of freedom (d.o.f.s) linearly dependent on one or more other (independent) d.o.f.s.
LOAD	defines nodal loads and load combinations.
NAME	gives a name to a superelement. This is only relevant in connection with the LOAD ASSEMBLY command.
OPTIMIZE	optimises the node numbering in order to minimise the bandwidth of the stiffness matrix of higher level superelements.
PLOT	generates a plot file of the current display. The plot file may be printed or imported in a word processor. In a MS Windows environment the plot may also be directed to an on-line printer.
PRINT	prints tables over model data. The tables may be directed to the screen or to a file by the SET PRINT command.
READ	reads Input Interface Files containing descriptions of first level superelements.

ROTATE	rotates the display of the superelement.
SET	sets and defines various control parameters.
TAG	tags selected nodes. These may subsequently be referred to as TAGGED within, for example, the BOUNDARY command.
TASK	switches to input mode for Submod; see the Submod User Manual. (In most cases you will find it more convenient to access Submod directly rather than through Presel.)
TRANSFORMATION	defines transformations that can be referred to when defining loads and boundary conditions.
UNTAG	resets node tags.
WRITE	writes Input Interface Files for higher level superelements. See Section 2.3 on this.
ZOOM	increases or decreases the scale of the display.
#	reads commands from a command input file defined by the SET COMMAND-INPUT-FILE command.
DELETE	deletes data.
EXIT	exits from Presel. The model and log files are saved and closed.

2.3 Transfer of the Model through the Input Interface File

As is the case for all SESAM preprocessors, the model created by Presel is transferred to the hydrodynamic and/or structural analysis programs via the Input Interface File which forms a part of the SESAM Interface File system. Figure 2.1 illustrates this transfer of models between the preprocessors and the analysis programs.

The Input Interface File, the T-file, is a sequential ASCII character file with 80 character long records. The straightforward definition of the file enables external programs to be connected to the SESAM system with comparative ease.

One interface file will be created for each superelement. The name of the file will be:

prefixT#.FEM

where:

- ‘prefix’ is an optional character string that may and may not include a directory specification, the string is given when entering Presel and is common for all superelements in the model.
- ‘T’ is a mandatory character identifying this as an Input Interface File, a T-file, as opposed to a Loads Interface File, L-file, which uses character L and a Results Interface File, R-file, which uses character R.
- ‘#’ is the superelement number, the identifier of the superelement.

- ‘FEM’ is a mandatory file extension.

Normally, the user may find it convenient to leave the prefix void. This is also the default condition.

An example of a name of an Input Interface File with prefix is:

ABCT5.FEM

Note that Presel both reads first level superelements and writes higher level superelements and all must have the same prefix. If the above file — superelement 5 — is one of several files of a superelement model then all Input Interface Files should be named ABCT#.FEM, where # is the superelement number.

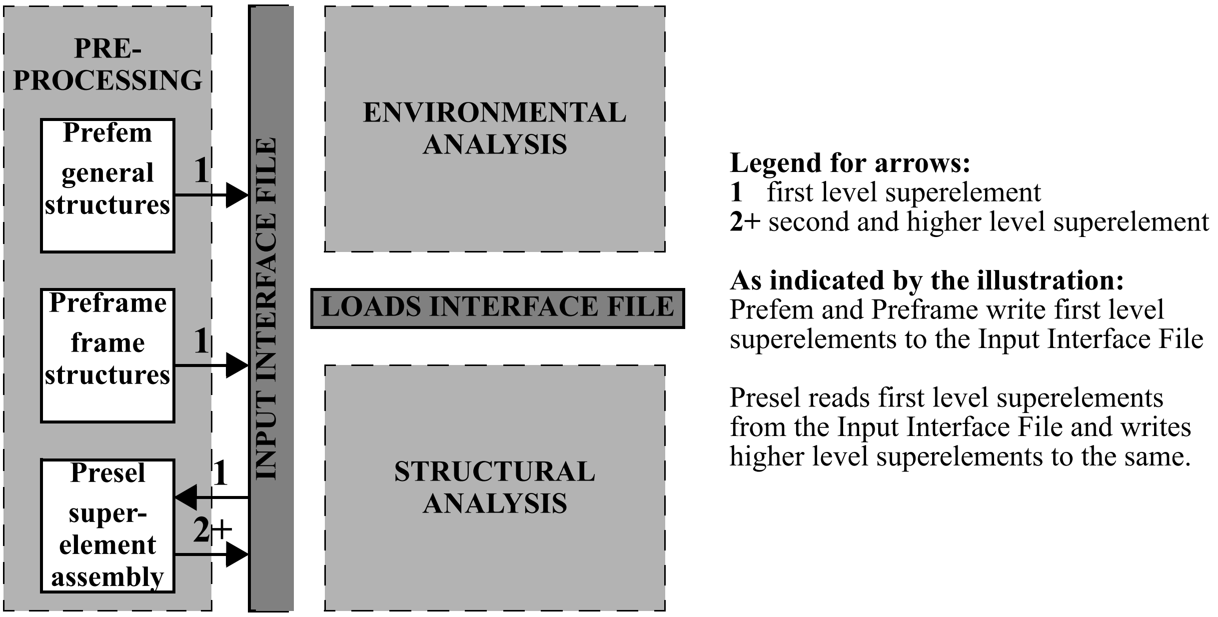


Figure 2.1 Interface between SESAM preprocessors and analysis programs

Presel produces Input Interface Files for all higher level superelements by the command WRITE:

WRITE top#

where top# is the number of the top level superelement. All higher level superelements are implicitly and automatically written when this command is given. Note that when the SESAM Manager is employed the writing of the top and higher level superelements is normally controlled by Manager thus making the WRITE command superfluous.

Note: If you on MS Windows close the Presel window by the X in the upper right corner (or by the Close (Alt+F4) command of the window menu) then the Input Interface Files will not be written even though you have requested this when starting Presel. This feature may be used if you change your mind and decide not to write the file after having started Presel.

3 USER'S GUIDE TO PRESEL

The purpose of Presel is to assemble (put together) part models, so-called first level superelements, to form the complete analysis model. This is done through the following steps:

- Read files of first level superelements (this is normally done automatically).
- Create a second level superelement assembly and include first level superelements into it. The inclusion process comprises positioning the first level superelements and coupling matching supernodes.
- Combine loads for the assembly by referring to loads of the first level superelements. Possibly also define some boundary conditions.
- Create higher level superelement assemblies, combine loads and define boundary conditions in the same way as explained above only now include previously created superelement assemblies. Repeat this process until the complete analysis model has been created.
- Store all superlement assemblies (the whole superelement hierarchy) on file and exit Presel (the storing is normally done automatically when exiting Presel).

This user's guide explains how to:

- Get started using the graphical user interface. See Section 3.1.
- Create the complete model by assembling superelements. See Section 3.2.
- Establish the loads for the complete model by combining loads on superelements. See Section 3.3.
- Assemble loads, an alternative and advanced way of establishing the loads. See Section 3.4.
- Define boundary conditions. See Section 3.5.
- Define linear dependencies. See Section 3.6.
- Display and print data. See Section 3.8.

- Use the superelement technique in a practical way to efficiently solve problems. See Section 3.9.
- Optimise node numbering (reduce bandwidth of the stiffness matrix) and when to do it. See Section 3.10.

3.1 Getting Started — the Graphical User Interface

Assuming you have started the SESAM Manager and that first level superelements have already been created then do as follows:

- Click **Options | Superelement** and within the window appearing set your analysis to be superelement analysis (as opposed to direct analysis) and specify top level superelement number (any number may be used).
- Start Presel by clicking **Model | Superelement Handling Presel** and click OK in the window then appearing.

The main part of the graphical user interface is the graphic-mode window. There are also a print window and a message window. Print requested by the user appears in the print window whereas various program messages appear in the message window. Figure 3.1 illustrates the three Presel windows.

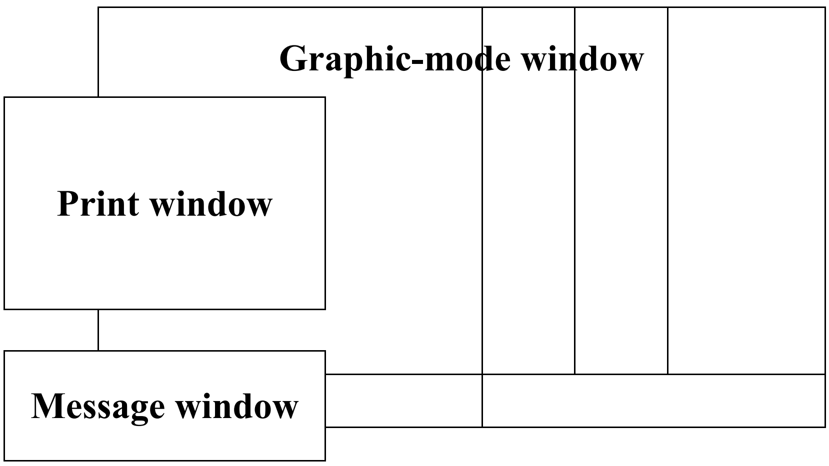


Figure 3.1 The Presel windows

Presel offers two modes of input and both are available in the graphic-mode window:

- Line-mode input, i.e. typing commands and data using the keyboard
- Graphic-mode input, i.e. selecting commands by clicking the left mouse button (LMB)

A sketch of the graphic-mode window is shown in Figure 3.2 together with explanations of the six different areas. How to use the areas is explained in more detail in the following.

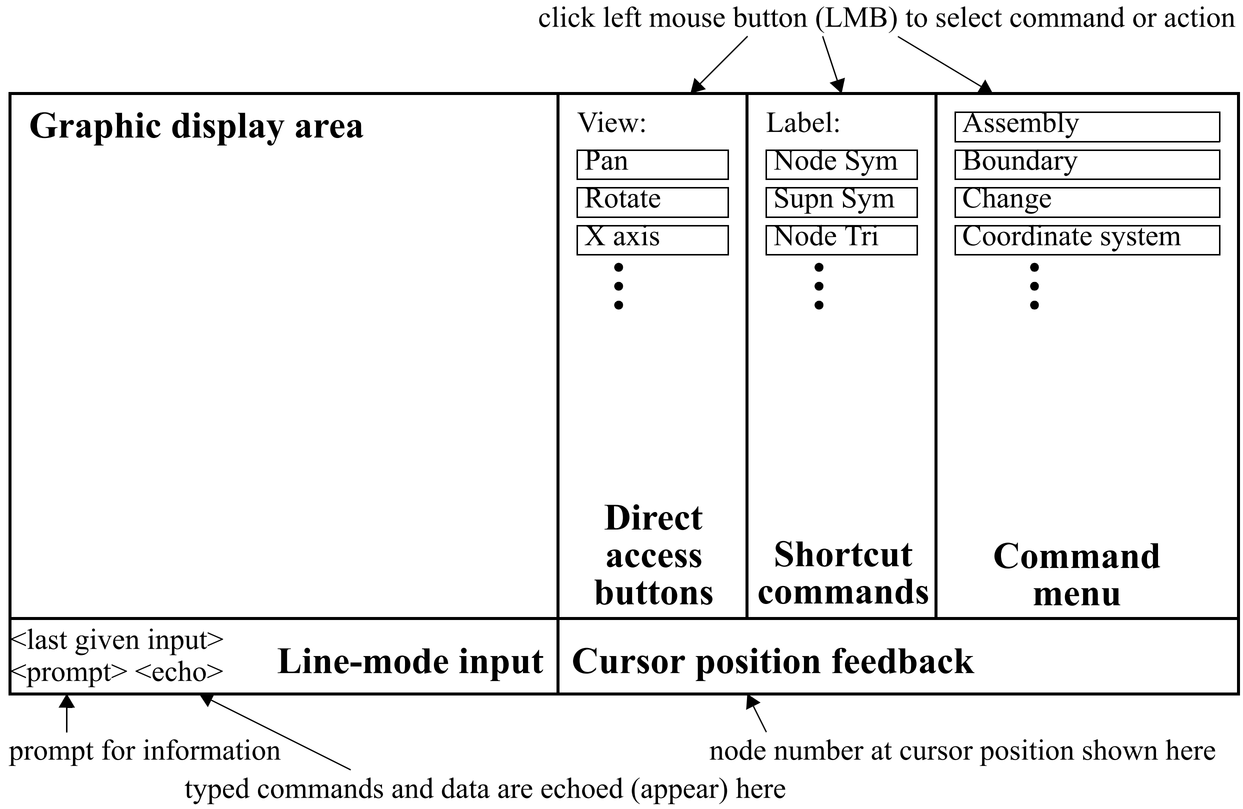


Figure 3.2 The graphic-mode window is composed of six different areas

You may at this stage decide to go through a Presel tutorial. Go then to Section 3.2.2 and use the explanations below of the areas of the graphic-mode window for reference.

The six different areas of the graphic-mode window are used as follows:

- **Graphic display area**
  - — The model (current or selected superelement) is displayed here.
  - — Within some commands (e.g. the BOUNDARY command) there is a need for selecting nodes. Alternatively to keying in the nodes as explained in Section 5.1 you may select nodes by clicking or dragging a rubberband in the graphic display area. The availability of graphical selection is subject to that node selection has been switched on by the SET GRAPHICS NODE-SELECTION command or by the ‘Sel Node’ shortcut command button. By default this is switched on.

- **Command menu**
  - — The at any time allowable commands plus default values for numerical data are listed here as buttons.
  - — Commands and values are selected by clicking the left mouse button (LMB).
  - — Slanted text signifies default choices that are accepted by either:
    - Hitting the Return key

  - Clicking either of the Direct access buttons ‘;’ (semicolon) and ‘/ /’ (double slash). The former accepts all subsequent default values (see Section 4.1.2) while the latter accepts a single default value, i.e. the one shown in slanted font.

- **Shortcut commands**

  These provide one-click access to commonly used compound commands. A Shortcut command is logged as its equivalent full standard commands.

- **Direct access buttons**

  These buttons are accessible at any time. I.e. when you are in the middle of a command (by clicking a command or a shortcut command or by typing a line-mode command) you may rotate and zoom to get a better view. The buttons ‘;’ and ‘/ /’ are logged with the default values they accept. The button ‘..’ is logged as is. The other buttons are not logged (see Section 4.1.3 on logging commands).

  — The **Pan** button allows panning (shifting) the display. Click the button, then press and hold the LMB within the Graphic display area and a bounding box of the displayed model appears. Move the mouse and release the LMB and the model will be displayed in its new position.

  — The **Rotate** button allows interactive rotation of the display. Click the button, then press and hold the LMB within the Graphic display area and a bounding box of the displayed model appears. Move the mouse up and down to rotate the model about a screen horizontal axis and move left and right to rotate about a screen vertical axis. A circular motion will rotate the model about an axis normal to the screen in the *opposite* direction of the circular motion. When the LMB is released the model is displayed in its new position.

  — The **X axis**, **Y axis** and **Z axis** buttons display the model as seen along the model’s X-, Y- and Z-axis, respectively.

  — The **Default** button switches back to the default viewing position (optionally set in Manager) and re-displays the model.

  — The **Zoom In** button zooms in by either clicking twice and diagonally or by pressing the LMB and dragging it to form a zoom area (rubberband box).

  — The **Zoom Fr** button re-displays the model so that it fits within the display area.

  — The **Learn** button offers making a new Shortcut command. Click the button and enter a maximum eight character string being the name of the new Shortcut command and hit Return. Now give any sequence of commands. Several complete commands may be given, the last of which may be incomplete (i.e. more data is required to make it complete). Clicking the Learn button once more completes the process and the new Shortcut command appears as a new button.

  — The ‘**;**’ button accepts all available default commands and parameters.

  — The ‘**..**’ button aborts the current command.

  — The ‘/ /’ button accepts a single default value, i.e. the one shown in slanted font.

  — The **Node** button (under heading Select) is merely a consequence of GUI consistency with other SESAM preprocessors and has little relevance for Presel. It must be depressed (the default condition) to allow graphical selection (clicking and rubberband) of nodes.

  — The **Set** button (under heading Select) is merely a consequence of GUI consistency with other SESAM preprocessors and has little relevance for Presel.

- **Line-mode input**

  — The upper line presents the last given input.

— The lower line includes the prompt for input and data entered in line-mode.

— You may paste (Ctrl+V) text into the line-mode input area.

- **Cursor position feedback**

  — The node number triplet of the node at or close to the cursor position is listed here. If more than one node is within the tolerance of the cursor position then the triplets of all these nodes will be listed.

Note: While entering a command by the keyboard it is not possible to click buttons or commands until hitting the Return key or deleting all data typed. This involves that if you (inadvertently) have entered a 'space character' (which you may overlook as you cannot see it) clicking commands as well as selecting nodes and elements by clicking will not work. Use the backspace to delete the 'space character(s)'.

3.2 Assemble Superelements

This section explains how to assemble superelements to form the complete model. The basic procedure is first briefly explained, thereafter a small example (tutorial) is used to illustrate the procedure.

3.2.1 Basic Procedure

1 Store all first level superelements in the Presel database by reading the SESAM Input Interface Files (T-files named T#.FEM). Use the command READ. This is optionally done automatically when starting Presel from the SESAM Manager (select default Command input file).

2 Create a new superelement assembly. Use the command ASSEMBLY NEW. This superelement is initially empty but it will become a second level superelement once a first level superelement has been included.

  a Include a first level superelement in the new superelement assembly by the following process:

    1 Start the inclusion process by the command INCLUDE.

    2 If necessary, translate, rotate and mirror the first level superelement to its proper position in the assembly. See the INCLUDE command for the alternative positioning commands.

    3 Verify graphically its position by the command DISPLAY.

    4 Check that the supernodes of the first level superelement match the nodes of the already included superelements, if any. Use the command NOPRINT-CHECK-INCLUDE.

    5 Complete the inclusion process by the command PERFORM-INCLUDE.

    6 Verify the inclusion by the LABEL COUPLED-NODES and other commands.

  b Include other first level superelements by repeating the process above (item a).

  c When the assembly, which has now become a second level superelement, is complete then give appropriate boundary conditions. This may be fixations and/or supernodes for coupling with other superelements. Use the command BOUNDARY.

d At this stage you may define load cases for the assembly. This task may, however, also be postponed to after the complete model has been assembled. See Section 3.3 on this.

3 Create new second level superelements by repeating the process above (item 2).

4 Create new superelements at level three and higher levels by repeating the process above (item 2). The only difference from creating second level superelements is that not only first level superelements are included. Any mixture of first and higher level superelements may be included in the same new superelement. The level of the new superelement will be equal to the level of the highest level of the included superelements plus one.

5 The assembly process is concluded when the top level superelement representing the complete model has been created. Supernodes *cannot* be defined for the top level superelement.

6 You should now define the loads for the various higher level superelements (ref. item 2 d above). See Section 3.3 on this.

3.2.2 Tutorial in Assembling Superelements

The tutorial below illustrates how two first level superelements may be assembled to form a second level superelement. Figure 3.3 shows the two first level superelements as well as the complete model. For each first level superelement the dimensions, the origin, the free (internal) nodes and the supernodes are given. As can be seen, superelement 5 is used once and superelement 6 is used twice to form the complete model.

If you only want to read this section, i.e. you do not intend to perform the tutorial, then you may skip the four-item list of required actions below.

If you want to perform the tutorial and run Presel for this example, you first need to do the following:

- Start the SESAM Manager and open a new project. When doing so click **Structure Type** and choose General. (You may also select type of structure after opening the new project by **Options | Structure Type**.)

- In Manager click **Options | Superelement** and within the window appearing set your analysis to be Superelement analysis (as opposed to Direct analysis) and set Top level superelement number to 7.

- Create the two first level superelements 5 and 6 by running Prefem twice. Remember to set the superelement number *before* starting Prefem. The input for the two superelements is provided in Appendix A TUTORIAL EXAMPLES, Section A 1. Rather than clicking/typing the commands you may want to create two command input files using an editor. Note that node numbers in a FE model are automatically generated by Prefem and may with a new program version deviate from the numbers shown in Figure 3.3.

- Start Presel as follows: Click **Model | Superelement Handling Presel** to open the Superelement handling window. Make sure the Command input file selected is Default and click OK. This default Command input file reads the T#.FEM files located in the project area. (Optionally, you may read the superelements 5 and 6 using the READ command.)

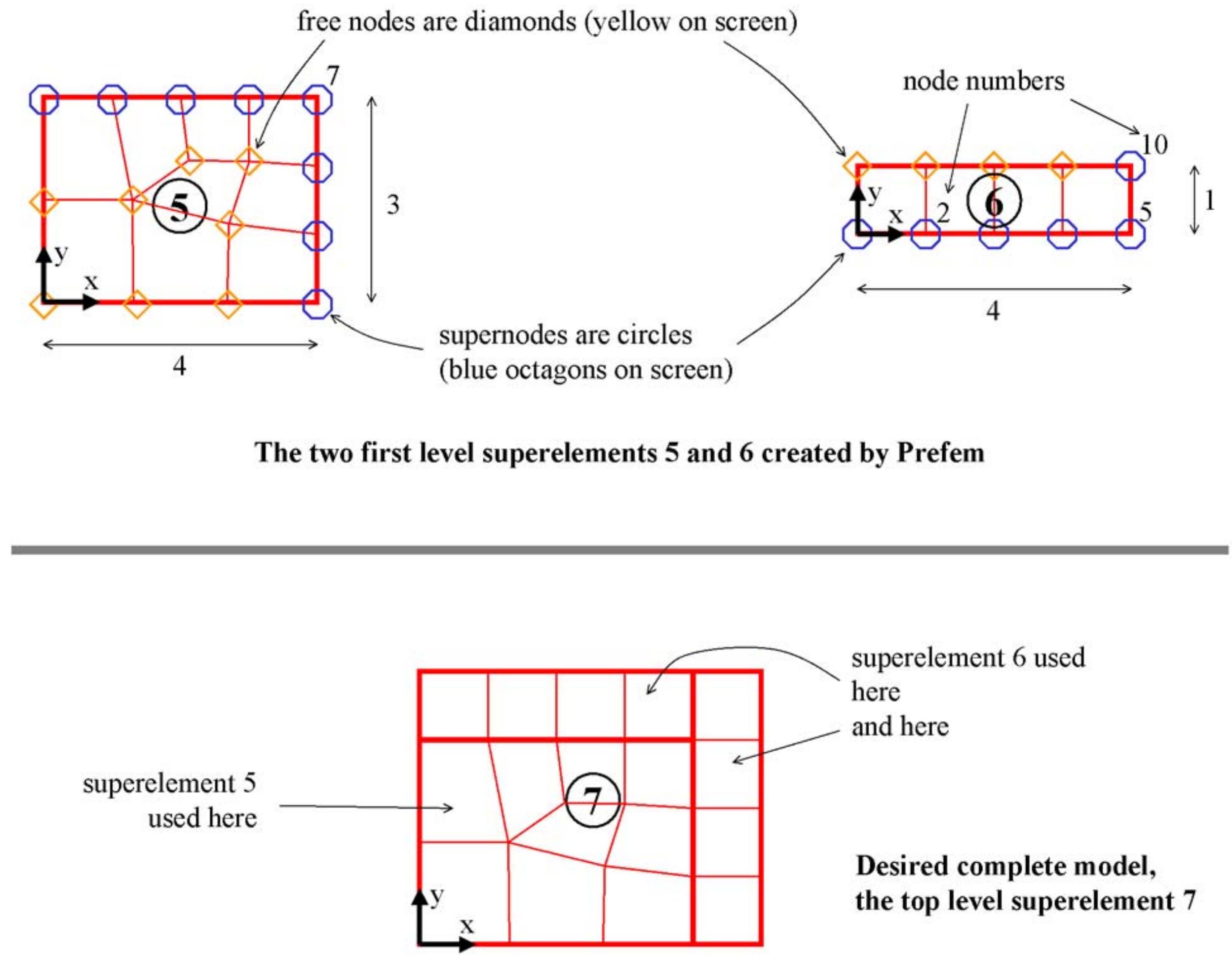


Figure 3.3 The two first level superelements and desired complete model

Figure 3.4 and Figure 3.5 take you step-by-step through the procedure and commands for assembling superelements 5 and 6 to form the complete model, superelement 7.

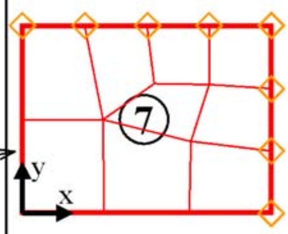
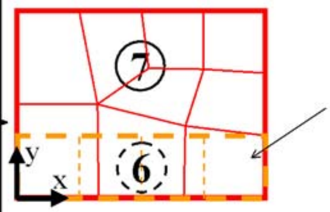
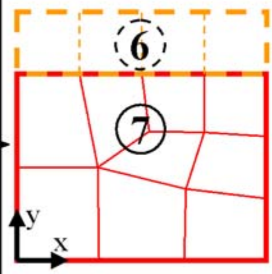
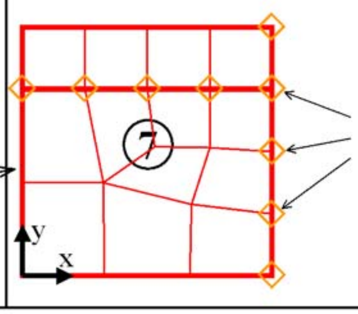
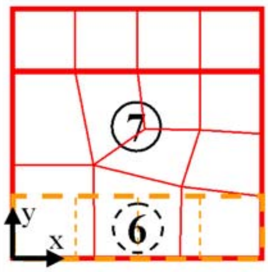
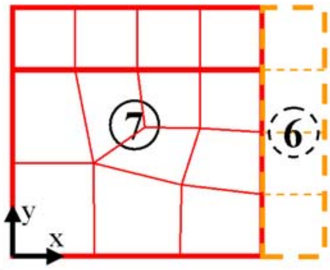
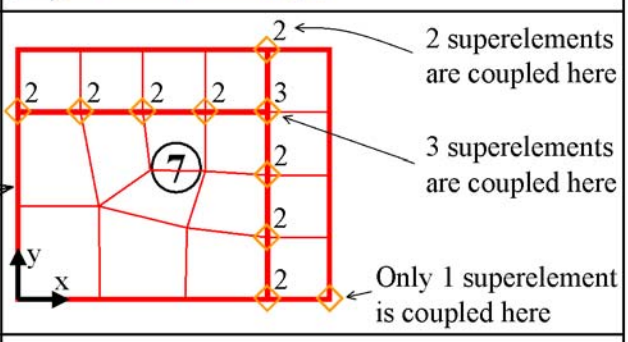
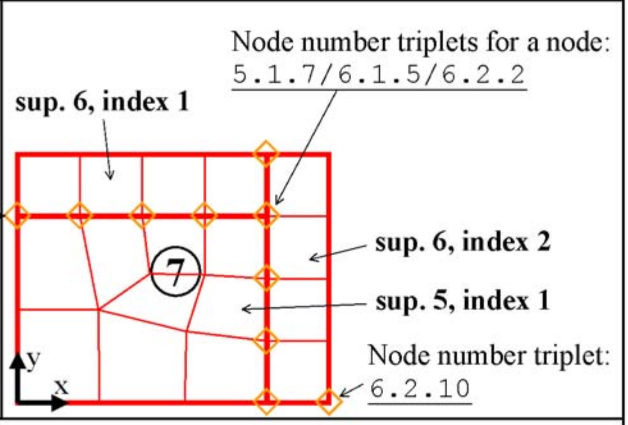
<table>
<tr><th>Commands to give</th><th>Superelements as shown by DISPLAY commands</th></tr>
<tr><td>READ 5
6
END
Omit these if default Command input file is used</td><td></td></tr>
<tr><td>ASSEMBLY NEW 7</td><td>There is nothing to display as the superelement is yet empty</td></tr>
<tr><td>INCLUDE 5
NOPRINT-CHECK-INCLUDE
PERFORM-INCLUDE
END
DISPLAY CURRENT-SUPERELEMENT
LABEL NODE-SYMBOL ALL
..</td><td></td></tr>
<tr><td>INCLUDE 6
DISPLAY</td><td>The superelement being included is displayed with broken lines.</td></tr>
<tr><td>TRANSLATE 0 3 0
DISPLAY</td><td></td></tr>
<tr><td>NOPRINT-CHECK-INCLUDE
PERFORM-INCLUDE
END
DISPLAY CURRENT-SUPERELEMENT
LABEL NODE-SYMBOL ALL
..</td><td>Notice that nodes that were supernodes at first level are free nodes at second level.</td></tr>
<tr><td colspan="2">The screen display will in principle be as shown above. Encircled superelement numbers are added here for pedagogic purposes. An origin symbol may be added by the LABEL ORIGIN-SYMBOL command.</td></tr>
</table>

Figure 3.4 The commands and resulting superelements

Commands to give	Superelements as shown by DISPLAY commands
`INCLUDE 6` `        DISPLAY`	

`        ROTATE GLOBAL-AXIS Z -90`
`        TRANSLATE 4 4 0`
`        DISPLAY`
	

`        NOPRINT-CHECK-INCLUDE`
`        PERFORM-INCLUDE`
`        END`
`DISPLAY CURRENT-SUPERELEMENT`
`LABEL NODE-SYMBOL ALL`
`      COUPLED-NODES`
`..`
	

`LABEL NODE-NUMBERS`
`        NODE-NUMBER-TRIPLET`
`        ALL-NODE-NUMBER-TRIPLETS`
`..`
	

The LABEL NODE-NUMBERS command above results in all node number triplets for all nodes to be shown. To avoid cluttering the figure triplets for two nodes only are shown. A triplet is composed of three numbers. The triplet 5.1.7 is composed of: 5 = first level superelement number, 1 = superelement index and 7 = node number. See following sections on superelement index and node number triplets.	

Figure 3.5 The commands and resulting superelements, continued

3.2.3 Auxiliary Commands

You may verify the superelement assembly by various auxiliary commands.

The LABEL COUPLED-NODES command used in Figure 3.4 and Figure 3.5 verifies that the appropriate number of first level superelements are indeed coupled. This is an important check because a minor coordinate difference, for example due to a modelling error, may involve that some nodes are not coupled even though they appear to be so in the display. A coordinate tolerance determines whether nodes are coupled or not. You can set this tolerance by the SET COORDINATE-TOLERANCE command. The LABEL NON-COUPLED-NODES is the complementary command labelling nodes adjoined by a *single* first level superelement by the digit 1. The node in the lower right corner of superelement 7 is such a node.

The command PRINT OVERVIEW-OF-SUPER-ELEMENTS produces a table over all first and higher level superelements. A double plus in the left margin of the table indicates which superelement is the *current* one. The DISPLAY command displays the *current* superelement, the INCLUDE command includes superelements into the *current* superelement, etc. For the example above the table looks like this:

```
SUPER EL.
TYPE       LEVEL      NODES      ELEMENTS   LOADCASES
---------  ---------  ---------  ---------  ---------
        5          1         16          9          3
        6          1         10          4          2
++      7          2         10          3          0
```

The command PRINT SUPER-ELEMENT-HIERARCHY produces a table illustrating the hierarchy. For the current example the table will be as shown below. It is common practice to manually sketch the superelement hierarchy as shown in Figure 3.4.

```
SUPER ELEMENT LEVEL
      2             1

-----1:7.1-----------1:5.1
            !
            !-----2:6.1
            !
            !-----3:6.2
```

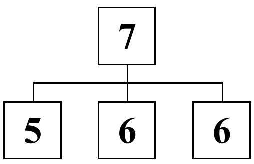


Figure 3.6 Sketch of superelement hierarchy

Also see Section 3.8 on display and print commands for verifying the model.

3.2.4 Identifying Superelement Occurrences

Since a superelement may be included any number of times in a model, each occurrence of the superelement is assigned a unique identification.

Within Presel there are two ways of uniquely identifying an occurrence of a superelement:

- By referring to its superelement number plus superelement index. The superelement index is the number in sequence in which the superelement was included; see below for a more complete explanation. In the LOAD COMBINATION command you need to refer to superelements in this way; see Section 3.3.2.
- By referring to name and location string as used in the LOAD ASSEMBLY command; see Section 3.4.

Yet another way is employed in Sestra for determining selective retracking (the SELID parameters on the RETR command in the Sestra input):

- By referring to the string of hierarchy branch numbers from the top level superelement and down to the superelement in question.

The hierarchy branch numbers, superelement numbers and superelement indexes are all given in the superelement hierarchy printed by Presel as shown in Section 3.2.3. Each superelement is identified by three numbers:

- *Branch number* within the superelement assembly.
- *Superelement number*.
- *Superelement index* — The first time a superelement number is included in an assembly it is assigned index 1. The second time it is included it is given index 2, and so on. When a higher level superelement is repeatedly included in an assembly the indexes of its included superelements will also be incremented. If, for instance, the second level superelement 7 in the current example were to be included twice in a third level superelement 9 then a superelement 5 with index 2 would appear, also two new occurrences of superelement 6 would appear, namely indexes 3 and 4; this is illustrated in Figure 3.7.

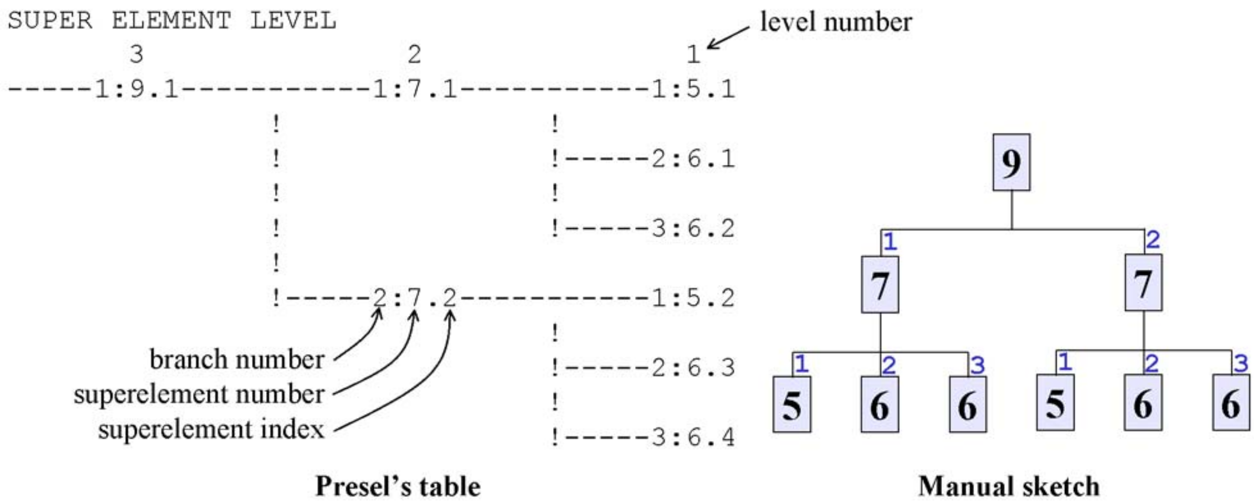


Figure 3.7 Superelement hierarchy — second level superelement 7 included twice in third level 9

3.2.5 Identifying Nodes in a Superelement Model

In a superelement model it is easily recognised that the node number itself is not enough information to uniquely identify a node. In particular, when a superelement is included several times a particular node will appear in several positions. Therefore, additional information is required to identify a specific node in the complete model.

A specific node in a superelement model is uniquely identified by so-called node number triplets:

i.j.k

where i is superelement number, j is superelement index, and k is node number.

Figure 3.5 includes a sketch of a model showing node number triplets for a couple of nodes.

3.2.6 More About Nodes

Nodes in a superelement hierarchy have the following characteristics:

- Nodes of a higher level superelement are the *union of the supernodes of the included superelements*.
- Nodes of a superelement not defined as super will *not exist in a higher level assembly* into which the superelement is included. Therefore, nodes not defined as super for the first level superelements (in Prefem or Preframe) will not exist as far as Presel is concerned.
- Nodes may be defined as super or given any other boundary condition only for the *current* higher level superelement.
- Nodes are identified by node number triplets: 'superelement.index.node'. See Section 3.2.5.
- A node has as many triplets as there are first level superelements coupled to the node. Any of these triplets are unique identifications of the node.
- Any selection of the six degrees of freedom (d.o.f.) of a node may be defined as super d.o.f. (the solid and membrane elements have only three d.o.f.).

Note: If a superelement is to be rotated or mirrored then either all three translational d.o.f.s, or all three rotational d.o.f.s, or all six d.o.f.s must be super. (The reason for this is explained in Appendix B THEORY, Section B 1.3.)

Note: Nodes to couple must have equal sets of super d.o.f. For example, both may have all 6 d.o.f. as super, which is the most common case, or both may have the translations in x and y and rotation about z as super, etc.

In Presel commands like BOUNDARY, LOAD, PRINT and TAG you need to select nodes. Section 5.1 explains how this is done.

3.3 Combine Loads

This section explains how to establish the loads for the complete model by combining loads for higher level superelements. The motivation for combining loads is first explained in Section 3.3.1 and thereafter exemplified in Section 3.3.2 employing the tutorial of Section 3.2.2.

There are three alternative methods for combining loads:

- LOAD COMBINATION — 'one-by-one'

  This is the basic and explicit method for combining loads, it is exemplified in Section 3.3.2.

- LOAD COMBINATION GROUP — 'group of loads'

  For models comprised of several superelements and a number of load cases the 'one-by-one' method will involve a considerable amount of input. If all superelement occurrences have the same number of loads numbered from 1 and up — as is the case e.g. for an offshore structure subjected to wave loads — the 'group of loads' method reduces the amount of input. Section 3.3.4 explains this.

- LOAD ASSEMBLY

  This is an even more advanced method for combining loads. Section 3.4 explains this.

3.3.1 Why Combine Loads

Since superelements may be used repeatedly to establish the complete model a certain superelement number may be found in several different locations in the model, each location termed a superelement occurrence and identified by an index number. These different superelement occurrences will typically be subjected to different loads. For example, for a model submerged in water two occurrences of the same superelement will, due to their different positions, be subjected to different water pressures. To account for this one loading condition is represented by two different load cases when modelling the superelement in Prefem or Preframe. These two load cases then need to be put together, i.e. combined, when the superelements are assembled.

Combining loads is in effect assigning the proper load to the proper superelement occurrence. In this process the different superelement occurrences need to be identified. This is done by referring to two numbers: the superelement number and the superelement index. Section 3.2.4 explains the superelement index.

Note: Only the load combinations made for the top level superelement are the loads analysed in Sestra and available for postprocessing. I.e. a load case that not directly or through intermediate combinations contributes to a top level load combination has no effect.

3.3.2 Tutorial in Combining Loads One-by-One

This tutorial is based on the same example as the tutorial in assembling superelements, Section 3.2.2. You should do the tutorial in assembling superelements first. You should also read Section 3.3 and Section 3.3.1.

The loads for the example of Section 3.2.2 are shown in Figure 3.8. Both the local loads for the two first level superelements (loads defined in e.g. Prefem) and the desired global loads for the complete model are shown.

As you will see this tutorial does not have loads numbered from 1 and up. This will result in zero loads filling in the gaps in the load numbering thereby consuming some additional computational time and disk space. This is, therefore, in conflict with normal and advisable practice. The reason for numbering the loads like this is merely to avoid confusion in the tutorial between loads, superelement numbers and superelement indexes.

Note: Number the load cases and combinations from 1 and up to avoid zero load cases which would result in waste of computational time and disk space.

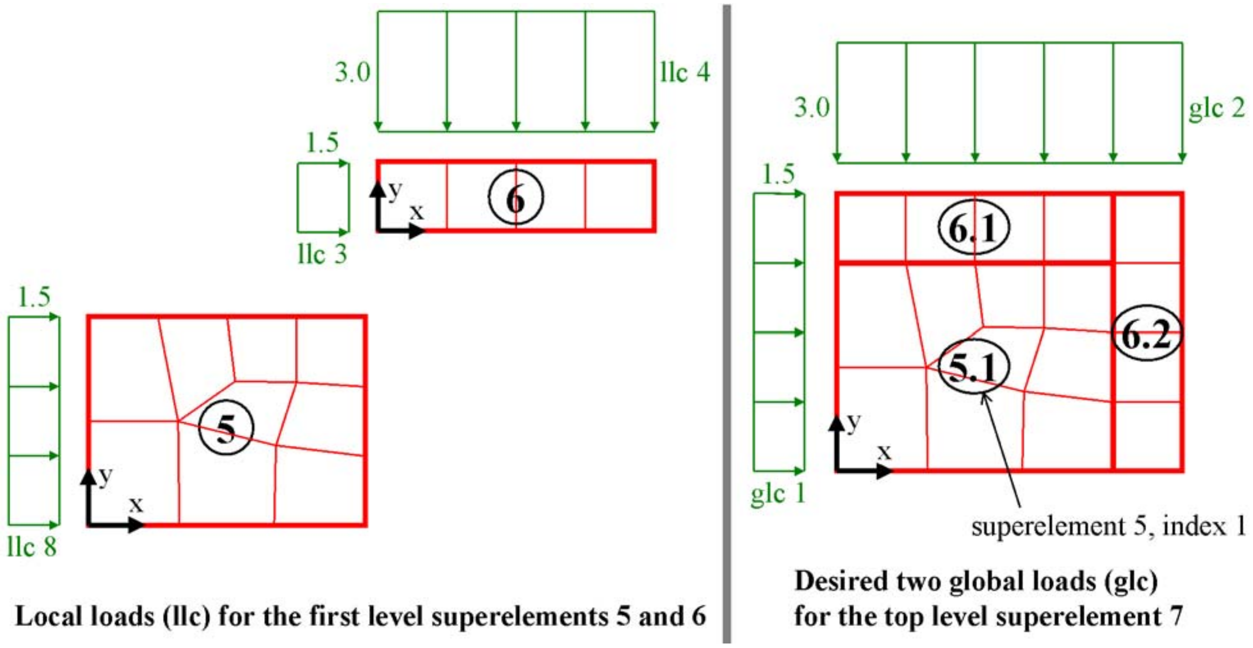


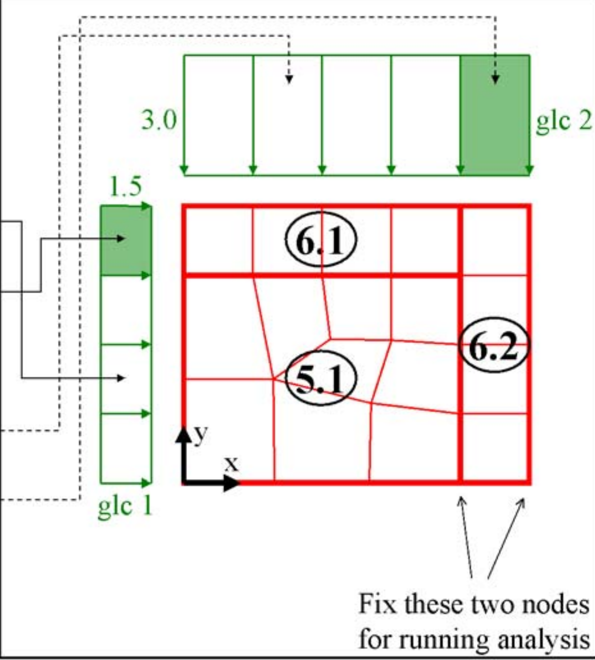
Figure 3.8 Loads modelled for the first level superelements and desired loads for the complete model

Figure 3.9 takes you step-by-step through the commands for establishing the desired global loads. Notes explaining the data to enter are also provided.

Commands to give

```
  % Load combinations for sup.el. 7:
  ASSEMBLY OLD 7
  %
  LOAD COMBINATION
  % Define global load 1:
  %        glc sup indx llc  factor
1            1   5    1   8    1.0
                          END
2
3                6    1   3    1.0
                          END
4
5                END
  % Define global load 2:
6            2   6    1   4    1.0
                          END
                 6    2   3    2.0
                          END
                 END
7            END
        END
```

Global loads



	Notes referring to the numbers to the left above:
1	Global load 1 is defined. Superelement 5, index 1, contributes with local load 8 with factor 1.0.
2	END means that superelement 5, index 1, contributes with no more local loads to global load 1.
3	Superelement 6, index 1, contributes with local load 3 with factor 1.0 to global load 1.
4	END means that superelement 6, index 1, contributes with no more local loads to global load 1.
5	END means that no more superelements will contribute to global load 1, it is now complete.
6	Global load 2 is defined. Superelement 6, index 1, contributes with local load 4 with factor 1.0 and superelement 6, index 2, contributes with local load 3 with factor 2.0.
7	No more global loads (combinations) are defined.

Figure 3.9 The commands and resulting loads

If you at this stage want to continue the exercise by running the model through a structural analysis in Sestra you need to fix the model in space. You may for example fix the two nodes along the X-axis (see the sketch in Figure 3.9) by giving the command:

```
BOUNDARY FIX FIX FIX FIX FIX FIX GLOBAL
SELECT LINE INFINITE COORDINATE 0 0 0 COORDINATE 1 0 0 END
```

Then leave Presel by clicking EXIT. (If you do not use Manager you must give the command WRITE 7 before exiting Presel to produce the T7.FEM file for top level superelement 7. If you do use Manager you must have checked **Write top level superelement on exit** when starting Presel.) The model is now complete and may be analysed using Sestra and the results may be presented by Xtract.

If you are a new user you may at this stage want to learn about the effect on loads of rotating and mirroring superelements by reading Section 3.3.3. Other sections of interest to the new user are Section 3.5 Boundary

Conditions, Section 3.8 Display and Print and Section 3.9 Practical and Efficient Application of the Superelement Technique.

3.3.3 Effect on Loads of Rotating and Mirroring Superelements

If a superelement is rotated and/or mirrored when being included in a superelement assembly, its loads are rotated and/or mirrored too. This is exemplified in Section 3.3.2 where load 3 on superelement 6, see Figure 3.8, is rotated (and multiplied by 2) when being combined into global load 2 of top level superelement 7; see Figure 3.9. A mathematical explanation of this is found in Appendix B THEORY, Section B 1.3.

Figure 3.10 illustrates this. A, B and C are loads that rotate or mirror with the superelement to new positions A', B' and C'.

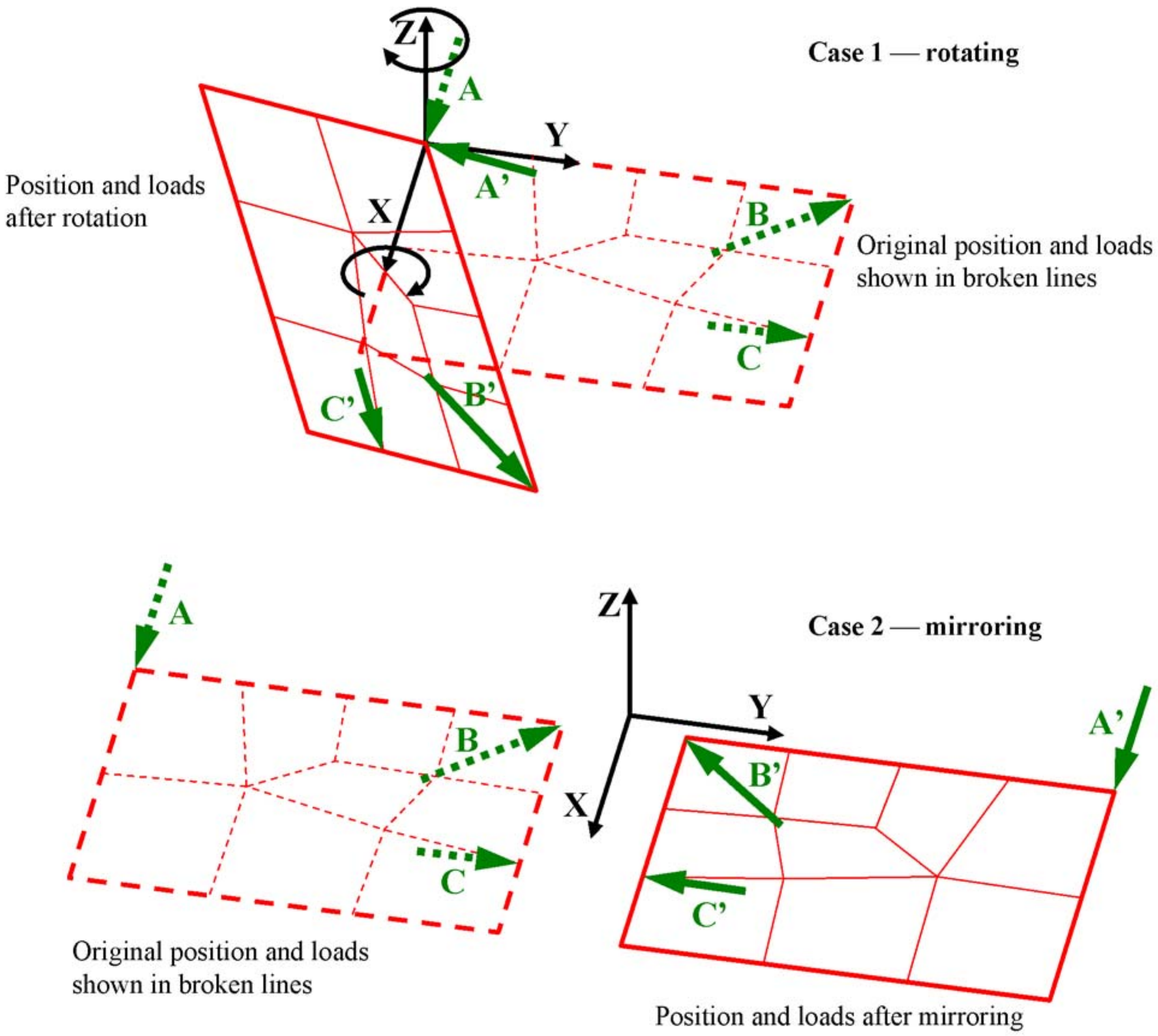


Figure 3.10 Loads are rotated and mirrored along with the superelement

3.3.4 Combining Wave Loads by the Group Method

This method for combining loads is quite general. Nevertheless, it is explained below with reference to a structure subjected to wave loads (an offshore or a ship structure) as this is the typical example in SESAM.

A model is typically comprised of several superelements. Wajac or Wadam are employed for computing a number of wave loads, e.g. 8 wave directions and 12 wave frequencies for each direction, altogether 96 load cases for each occurrence of all superelements. Combining all these load cases for all these superelements through all the superelement levels to the top will require a considerable amount of input. The LOAD COMBINATION GROUP command reduces this input to a manageable amount.

Note: Wave loads computed by Wajac and Wadam are stored on Loads Interface Files, the L#.FEM files. These files are not read by Presel. This means that the load combination — whether this is done by the one-by-one, group or assembly method — is performed without the program having knowledge about the existence of the wave loads. Therefore, when referring to a wave load in the load combination a warning is issued saying that the load case is accepted but it must be computed by a load program prior to performing the analysis.

The LOAD COMBINATION GROUP command is explained below referring to the model of Section 3.2.2. We assume that the model is subjected to wave loading from 8 directions and 12 frequencies, altogether 96 global load cases. As there are two occurrences of superelement 6, indexes 1 and 2, there will be a double set of loads computed by the wave loading program for superelement 6. This means that the L5.FEM file will contain 96 loads whereas the L6.FEM file will contain 192 loads.

Note: There is a difference between Wajac and Wadam in the way they number the wave load cases when there are two or more occurrences of a superelement. Their numbering systems are as follows (in parentheses are given the numbering applicable to the current example). In Wajac all wave loads for the first occurrence come first (load cases 1, 2, 3, ... 96), thereafter follows all wave loads for the second occurrence (load cases 97, 98, 99, ... 192) and so on. See Figure 3.11. In Wadam the first wave load for all occurrences comes first (load cases 1 and 2), thereafter follows the second wave load for all occurrences (load cases 3 and 4), then the third wave load for all occurrences (load cases 5 and 6) and so on. See Figure 3.12

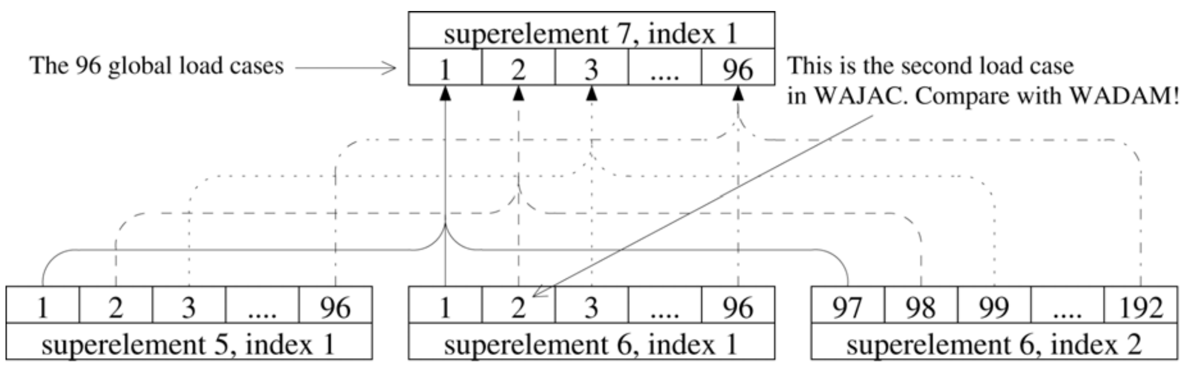


Figure 3.11 Wajac's numbering of load cases for superelement occurrences

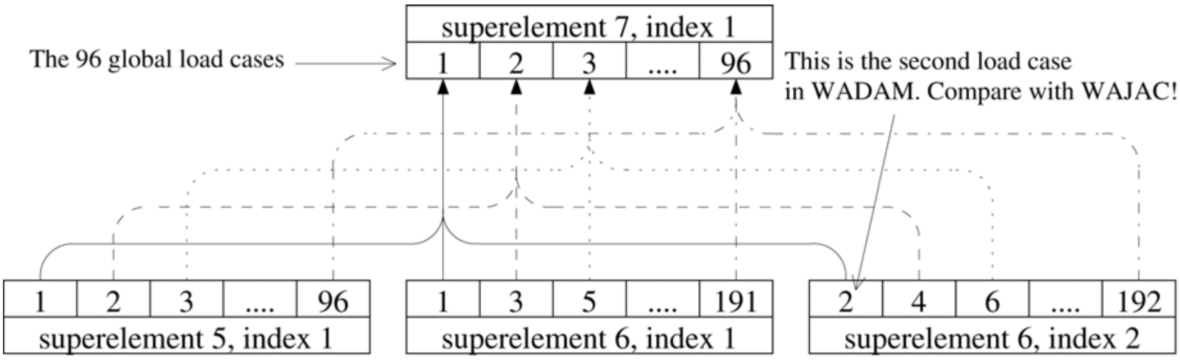


Figure 3.12 Wadam’s numbering of load cases for superelement occurrences

Load Combination Group for Wajac

Figure 3.11 illustrates how the load cases for the superelement occurrences must be combined to establish the global loads. The one-by-one method for combining loads computed by Wajac will for superelement 7 be:

```
%          glc sup indx   llc factor
LOAD COMB   1   5    1    1      1.0
                          END
                6    1    1      1.0
                          END
                6    2    97     1.0
                          END
                END
            2   5    1    2      1.0
                          END
                6    1    2      1.0
                          END
                6    2    98     1.0
                          END
                END
            3   5    1    3      1.0
                          END
                6    1    3      1.0
                          END
                6    2    99     1.0
                          END
                END
            :
```

etc. for each global load case up to the last one:

```
           96   5    1    96     1.0
                          END
                6    1    96     1.0
                          END
                6    2    192    1.0
```

```
                  END
        END
   END END
```

As can be seen the one-by-one method involves a lot of input (24 times the amount given above) even for such a small superelement hierarchy. For a large superelement hierarchy the amount of input will increase many times.

The group method involves considerably less input:

```
%                lowglc higlc step sup indx lowllc factor
LOAD COMB GROUP       1    96    1   5    1      1    1.0
                                     6    1      1    1.0
                                     6    2     97    1.0
                                     END
                     END END
```

This command says that global load cases 1 to 96 with step 1 will be created. The superelement occurrences (‘sup indx’) 5 1, 6 1 and 6 2 will contribute to these global load cases. For each occurrence only the local load case (‘lowllc’) corresponding to the first global load case is given, i.e. 1, 1 and 97 for the three occurrences, respectively. Implicitly, the command says that the global load cases 2, 3, etc. are defined by incrementing the local load cases in parallel. Also see the description of the LOAD COMBINATION command in Chapter 5.

The LOAD COMBINATION GROUP command must be given for each higher level superelement. Still, the amount of input is manageable.

Load Combination Group for Wadam

Figure 3.12 illustrates how the load cases for the superelement occurrences must be combined to establish the global loads. The one-by-one method for combining loads computed by Wadam will for superelement 7 be:

```
%         glc sup indx   llc factor
LOAD COMB   1   5    1   1      1.0
                         END
                6    1   1      1.0
                         END
                6    2   2      1.0    *
                         END
                END
            2   5    1   2      1.0
                         END
                6    1   3      1.0    *
                         END
                6    2   4      1.0    *
                         END
                END
            3   5    1   3      1.0
                         END
                6    1   5      1.0    *
                         END
                6    2   6      1.0    *
```

```
                     END
             END
           :
```

etc. for each global load case up to the last one:

```
          96   5    1   96      1.0
                        END
               6    1   191     1.0      *
                        END
               6    2   192     1.0
                        END
               END
          END END
```

Note: The asterisk above indicates lines of input deviating from the corresponding Wajac input.

As can be seen the one-by-one method involves a lot of input (24 times the amount given above) even for such a small superelement hierarchy. For a large superelement hierarchy the amount of input will increase many times.

The group method involves considerably less input:

```
%               lowglc higlc step sup indx          lowllc incr factor
LOAD COMB GROUP      1    96    1   5    1               1         1.0
                                    6    1    STEP       1    2    1.0
                                    6    2    STEP       2    2    1.0
                                    END
                          END END
```

This command says that global load cases 1 to 96 with step 1 will be created. The superelement occurrences (‘sup indx’) 5 1, 6 1 and 6 2 will contribute to these global load cases. For each occurrence only the local load case (‘lowllc’) corresponding to the first global load case is given, i.e. 1, 1 and 2 for the three occurrences, respectively. The command STEP given prior to the ‘lowllc’ for occurrences 6 1 and 6 2 means that the local load case is incremented by the value ‘incr’ = 2 for each increment of 1 of the global load case. Notice that STEP is not given for occurrence 5 1 and neither is an ‘incr’ value, this is because superelement 5 occurs only once.

Note: The STEP command is used for Wadam and not for Wajac.

The LOAD COMBINATION GROUP command must be given for each higher level superelement. Still, the amount of input is manageable.

Note: There is a requirement to the way the superelements are assembled to get a proper numbering of the wave loads computed by Wajac and Wadam. Section 3.3.6 explains this.

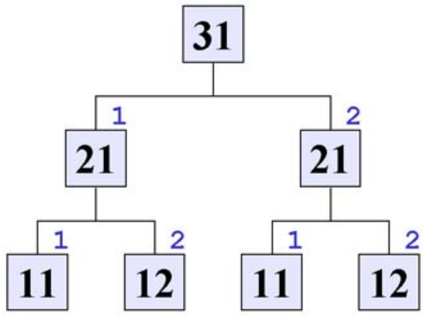
3.3.5 Load Combinations when Higher Level Superelements are Repeated

Figure 3.13 shows a superelement hierarchy in which superelements 11 and 12 are included in a superelement 21. And superelement 21 is included twice in superelement 31. As seen in the table printed by Presel superelement 11 appears in the *final assembly* with indexes 1 and 2. Index 2 comes into being when

superelement 21 is included in 31 the second time. Superelement 12 also appears with indexes 1 and 2 for the same reason.

```
---1:31.1-------1:21.1-------1:11.1
           !            !
           !            !---2:12.1
           !
           !---2:21.2-------1:11.2
                        !
                        !---2:12.2
```

Presel's table



Manual sketch

Figure 3.13 Superelement hierarchy with repeated higher level superelement

In the load combination, however, there will only be references to index 1 for superelements 11 and 12. This is because the higher level superelement 21 only recognises index 1 of superelements 11 and 12. It 'doesn't know' that itself is going to be included twice in superelement 31.

Let us assume that we have 8 wave load cases computed by Wadam. As both 11 and 12 are used twice Wadam will compute 16 loads for each superelement. When combining loads for superelement 21 we must, therefore, create 16 load combinations. Using the LOAD COMBINATION GROUP command the input will be:

```
%                lowglc higlc step sup indx         lowllc       factor
LOAD COMB GROUP       1    16    1  11    1              1          1.0
                                    12    1              1          1.0
                                    END
                     END END
```

The load combination for superelement 31 will be:

```
%                lowglc higlc step sup indx         lowllc incr factor
LOAD COMB GROUP       1     8    1  21    1     STEP     1    2     1.0
                                    21    2     STEP     2    2     1.0
                                    END
                     END END
```

3.3.6 Requirement to Assembling Process when Wave Loads are Computed

Note: Wajac and Wadam are based on the assumption that for all superelements the indexes are numbered consecutively (1, 2, 3, ...) when counting the individual superelements numbers from top to bottom in the table printed by Presel.

It is possible to assemble the superelements in such a way that the combination of wave loads computed by Wajac and Wadam will fail! A description follows below of (1) an awkward superelement hierarchy, (2) a hierarchy that fails in combination with Wajac and Wadam and (3) a proper hierarchy.

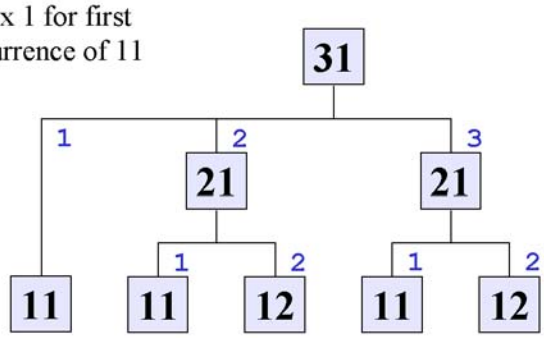
(1) Awkward Superelement Hierarchy

Consider the example of Figure 3.14. Superelement 11 is included in superelement 31 *prior* to superelement 21, i.e. 11 is found in branch 1 while 21 is found in branches 2 (and 3). Superelement 21 *also* includes 11. For this superelement hierarchy to be correct superelement 31 must be created (by ASSEMBLY NEW 31) and 11 included in 31 *prior to including 11 in 21*. 21 can of course not yet be included in 31 because it does not yet exist! Superelement 31 is therefore temporarily left incomplete and superelement 21 is created and completed by including 11 and 12. Then superelement 31 is completed by the commands ASSEMBLY OLD 31 and INCLUDE 21 twice. This ensures that the occurrence of superelement 11 at the top of the table printed by Presel is assigned index 1.

```
---1:31.1--------------------1:11.1
              !
              !---2:21.1-------1:11.2
              !             !
              !             !---2:12.1
              !
              !---3:21.2-------1:11.3
                            !
                            !---2:12.2
```

Index 1 for first occurrence of 11

Presel's table



Manual sketch

Figure 3.14 Awkward, though correct superelement hierarchy

(2) Incorrect Superelement Hierarchy

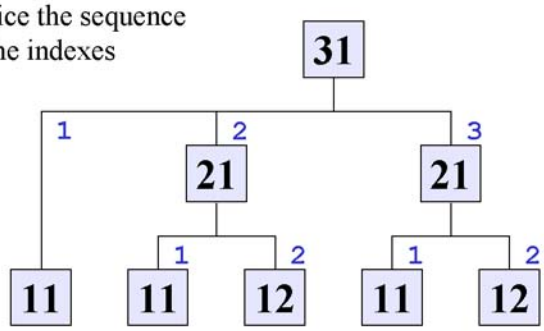
If you were to create superelement 21 and include 11 and 12 first and thereafter create 31 and include 11, 21 and 21 *in that order* the superelement hierarchy tabulated by Presel would be as shown in Figure 3.15. As seen, index 2 of superelement 11 comes before index 1 when counting superelement 11 from top and down.

Note: **If you establish your load combination input based on these indexes then you will get wrong results for wave loads computed by Wajac and Wadam! More specifically, the load case numbering will not correspond to the indexes as described in Section 3.3.4.**

```
---1:31.1--------------------1:11.2
             !
             !---2:21.1-------1:11.1
             !             !
             !             !---2:12.1
             !
             !---3:21.2-------1:11.3
                           !
                           !---2:12.2
```

Notice the sequence of the indexes

Presel's table



Manual sketch

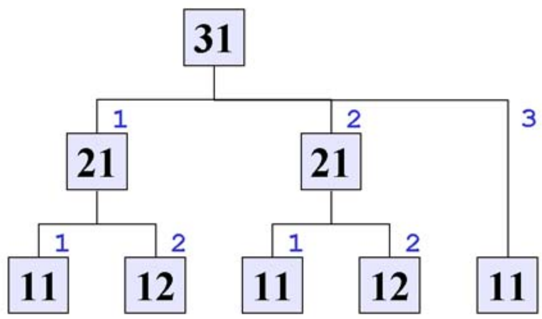
Figure 3.15 Incorrect superelement hierarchy

(3) Proper Superelement Hierarchy

Figure 3.16 shows a superelement hierarchy avoiding the problem described above. Superelement 21 is created first. Thereafter superelement 31 is created including superelements in the following order: 21, 21 and 11 at the end.

```
---1:31.1-------1:21.1-------1:11.1
             !             !
             !             !---2:12.1
             !
             !---2:21.2-------1:11.2
             !             !
             !             !---2:12.2
             !
             !----------------3:11.3
```

Presel's table



Manual sketch

Figure 3.16 Proper superelement hierarchy

3.4 Assemble Loads

When using the LOAD COMBINATION command explained in Section 3.3 you need to combine loads for *all* higher level superelements at *all* levels. For large superelement hierarchies with many loads this procedure involves a large amount of input. Load combination by the group method explained in Section 3.3.4 reduces the amount of input considerably compared to the one-by-one method explained in Section 3.3.2 but combinations must still be made for all superelements at all levels. A more advanced method is offered by the LOAD ASSEMBLY command. This involves making the load combinations directly for the top level superelement — the complete model — regardless of how many intermediate superelement levels there are.

To be able to use the LOAD ASSEMBLY command, unique identifications must be given for all occurrences of first level superelements for which loads exist. Giving such unique identifications makes the task of assembling the superelements more complex. But, as shown by the example below, defining the loads requires considerably less input.

There is another advantage of the load assembly method: The LOAD ASSEMBLY command will not be affected by changes to the superelement hierarchy. This is because the principle of this method is to give identifications for superelement occurrences depending on their *final location* in the complete model. The order in which the superelements are assembled is of no consequence.

3.4.1 Principles of Uniquely Identifying Superelement Occurrences

When a superelement is created by Prefem or Preframe it can be viewed as a building brick with no specific location in the complete model. The same can be said about any higher level superelement created in Presel. *Only* when the top level superelement is created then all lower level superelement occurrences, including the first level superelement occurrences, will have determined locations.

Note the terminology:

- *Superelement* is a building brick with no specific location.
- *Superelement occurrence* represents an actual part of a higher level superelement, it will have an *exact location in that higher level superelement*. If the higher level superelement is the top level superelement — the complete model — then the superelement occurrence also represents an actual part of the real structure.

It follows that only when the complete model is assembled the superelement occurrences may be given their final identifications. However, rather than assembling the whole model including the top level superelement before introducing the identifications a dynamic way of giving identifications is available. By ‘dynamic’ is meant that preliminary identifications are introduced and thereafter modified during the assembly process until the final identifications are determined when the complete model — the top level superelement — is created.

The identification of a superelement occurrence is composed of a name and a location string as follows:

name.location

The *name* is given to a superelement when it is created and is not changed during the assembly process. The *location* string is given when a superelement is included in a superelement assembly. The superelement has then become a superelement occurrence in that specific assembly. The *location* string is modified during the assembly process.

3.4.2 Tutorial in Assigning Unique Identifications for Superelement Occurrences

This tutorial takes you step-by-step through the procedure and commands for assigning unique identifications of superelement occurrences. If you want to run this example through Presel you first need to create the first level superelements employed. Appendix A TUTORIAL EXAMPLES, Section A 2, provides the input for these first level superelements. Refer to Section 3.2.2 for how to start Presel. In this case set top level superelement to 100.

In this tutorial five first level superelements shall be assembled to form a house as illustrated by Figure 3.17.

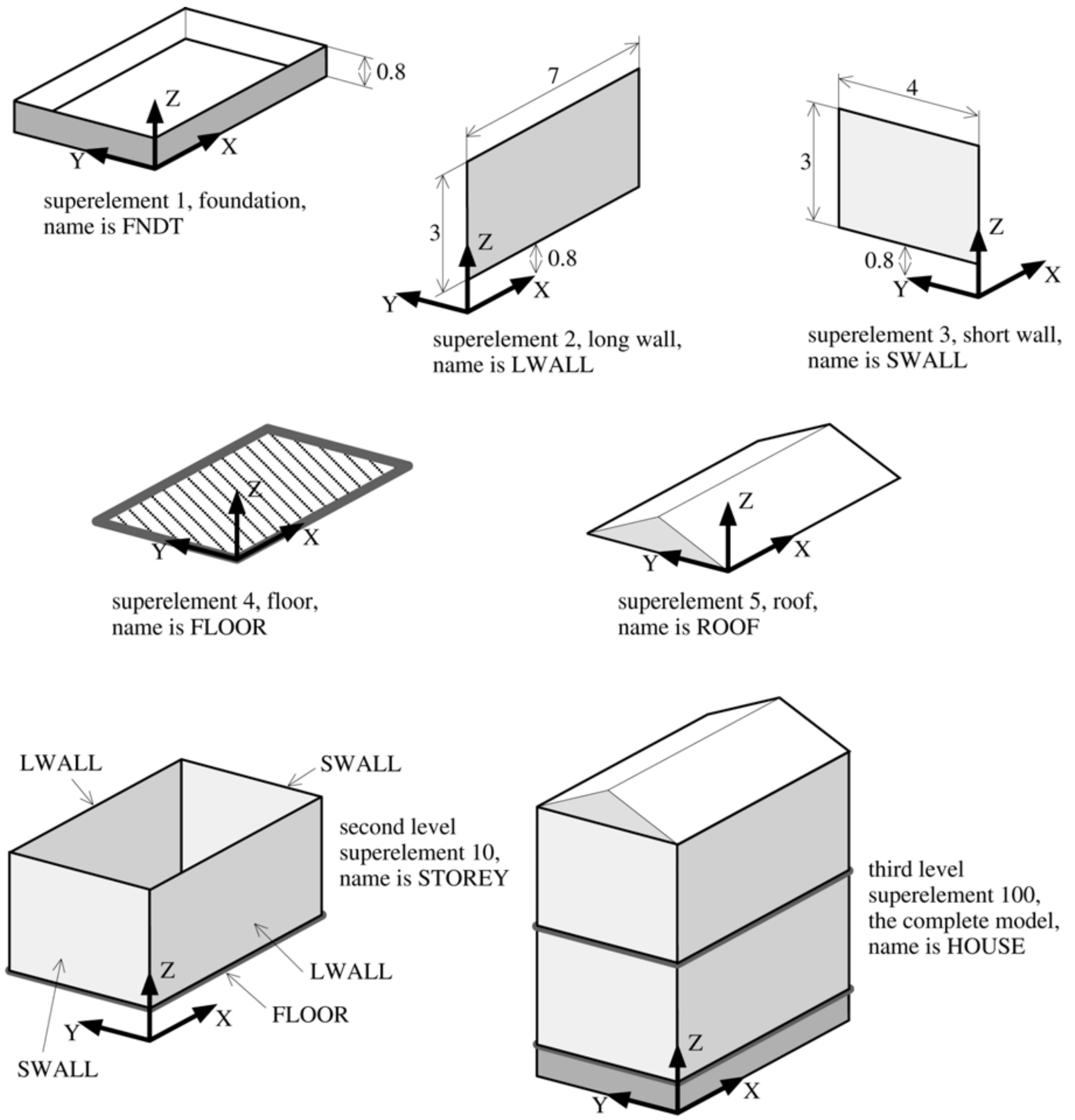


Figure 3.17 First, second and top (third) level superelements

After reading the first level superelements into Presel the first task is to assign names by the commands:

```
ASSEMBLY OLD 1
NAME CREATE FNDT
ASSEMBLY OLD 2
NAME CREATE LWALL
ASSEMBLY OLD 3
NAME CREATE SWALL
```

```
ASSEMBLY OLD 4
NAME CREATE FLOOR
ASSEMBLY OLD 5
NAME CREATE ROOF
```

Then the second level superelement 10 is created and given its name (names for higher level superelements are normally not required but included here for completeness):

```
ASSEMBLY NEW 10
NAME CREATE STOREY
```

When including superelements 2 (long wall) and 3 (short wall), twice each, and superelement 4 (floor) these are assigned location strings. The LOCATION CREATE command is used:

```
INCLUDE 2 NOPRINT-CHECK-INCLUDE
          LOCATION CREATE SOUTH
          PERFORM-INCLUDE
%
        3 NOPRINT-CHECK-INCLUDE
          LOCATION CREATE SOUTH
          PERFORM-INCLUDE
%
        2 TRANSLATE 0 4 0
          NOPRINT-CHECK-INCLUDE
          LOCATION CREATE NORTH
          PERFORM-INCLUDE
%
        3 TRANSLATE 7 0 0
          NOPRINT-CHECK-INCLUDE
          LOCATION CREATE NORTH
          PERFORM-INCLUDE
%
        4 TRANSLATE 0 0 0.8
          NOPRINT-CHECK-INCLUDE
          LOCATION CREATE BASIC
          PERFORM-INCLUDE
        END
```

Figure 3.18 shows the current identifications of the superelement occurrences included in superelement 10, STOREY. The short and long walls are given location strings corresponding to their southerly and northerly positions. The four wall superelements now have unique identifications in terms of names plus location strings. The floor is given the location string BASIC; it is neither southerly nor northerly.

Note: The LOAD ASSEMBLY command can only refer to superelement occurrences having location strings. Even a superelement not repeated and therefore having a unique name must be given a location string. The location string may be skipped for a superelement without loads.

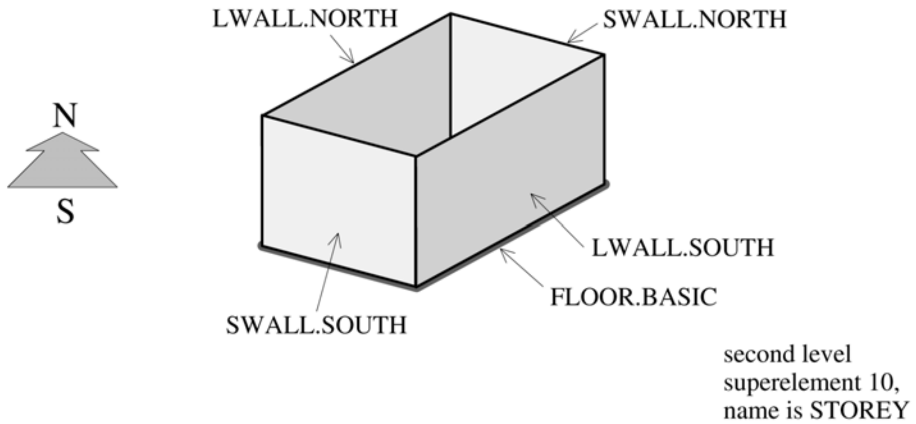


Figure 3.18 Identifications of superelement occurrences included in superelement 10, STOREY

Supernodes are then defined at the bottom and top planes for superelement 10, STOREY:

```
BOUNDARY SUPER SUPER SUPER SUPER SUPER SUPER GLOBAL
         SELECT PLANE 2-PLANE COORDINATE 0 0 0.8 COORDINATE 0 0 0
                PLANE 2-PLANE COORDINATE 0 0 3.8 COORDINATE 0 0 0
                END
```

Then the top level superelement 100 is created and given its name:

```
ASSEMBLY NEW 100
NAME CREATE HOUSE
```

Now, when including superelement 10 twice to make the two storeys of the house the location strings of the first level superelements included in 10 are assigned new location strings. The current strings are modified by the LOCATION USE command. The new location strings are more specific reflecting that the positions of the superelements in the complete model are more specific. The first inclusion of 10 is the ground floor, GRD is therefore added to the location strings. The second inclusion is the first floor, 1ST is therefore added to the location strings.

```
INCLUDE  1 NOPRINT-CHECK-INCLUDE
           LOCATION CREATE BASIC
           PERFORM-INCLUDE
%
        10 NOPRINT-CHECK-INCLUDE
%          Modify location for the south walls:
           LOCATION USE SOUTH SOUTHGRD
%          Modify location for the north walls:
           LOCATION USE NORTH NORTHGRD
%          Modify location for the floor:
           LOCATION USE BASIC BASICGRD
           PERFORM-INCLUDE
%
        10 TRANSLATE 0 0 3
           NOPRINT-CHECK-INCLUDE
%          Modify locations for all using wild-card:
           LOCATION USE * *1ST
```

```
          PERFORM-INCLUDE
%
        5 TRANSLATE 0 0 6.8
          NOPRINT-CHECK-INCLUDE
          LOCATION CREATE BASIC
          PERFORM-INCLUDE
        END
```

For the first inclusion of superelement 10 the location strings are modified one-by-one: The two superelement occurrences (LWALL and SWALL) having location string SOUTH get the new string SOUTHGRD, the two occurrences having location string NORTH get the new string NORTHGRD and the single occurrence having location string BASIC gets the new string BASICGRD.

But when all superelement occurrences shall have the same string added to their locations, as in this case, a wild-card notation can be used as shown for the second inclusion of superelement 10.

The foundation (1) and roof (5) superelements are included for the first time, the LOCATION CREATE command is used for these. They are given location strings BASIC as no specific identifications are required.

Note: If you give location strings also for higher level superelements then a wild-card reference in the LOAD ASSEMBLY command matching the higher level superelements will pick up loads from this superelement directly in addition to loads picked up from first level.

Therefore, LOCATION CREATE is not used when including 10 (STOREY) in the HOUSE below or else the wild-card *.* when defining load 1 (gravity) — see Section 3.4.3 — will pick up gravity loads from 10 *in addition* to gravity loads directly from first level. Gravity for parts of the model will erroneously contribute twice!

Figure 3.19 illustrates the final identifications of the superelement occurrences of superelement 100, HOUSE.

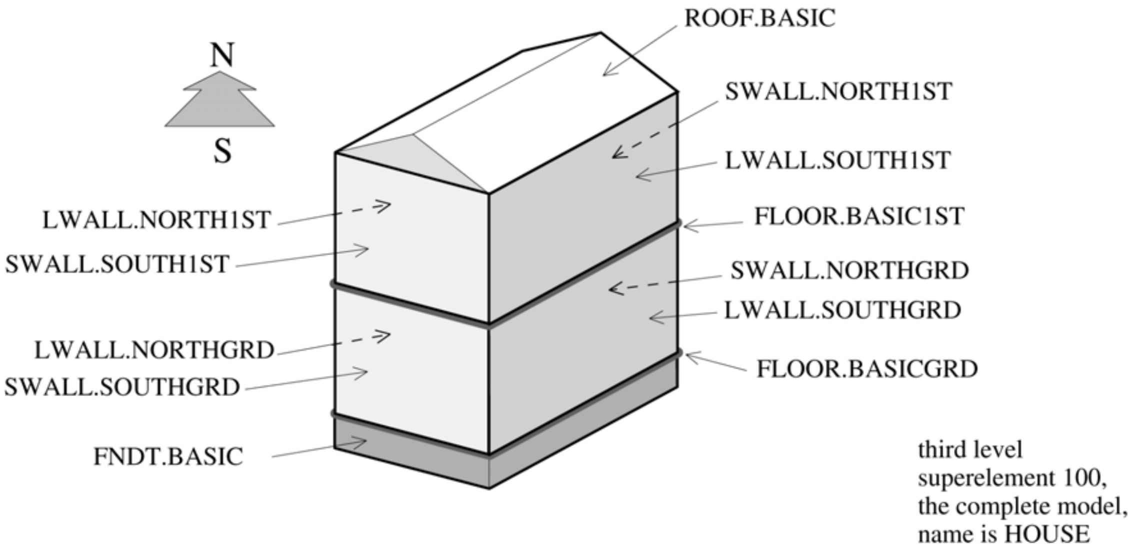


Figure 3.19 Identifications of superelement occurrences within superelement 100, HOUSE

Now the assembling of superelements including assigning of occurrence identifications is complete. Their identifications have become more specific in parallel with knowing more about their final positions. Figure 3.20 shows the superelement hierarchy with superelement numbers, indexes, names and location strings.

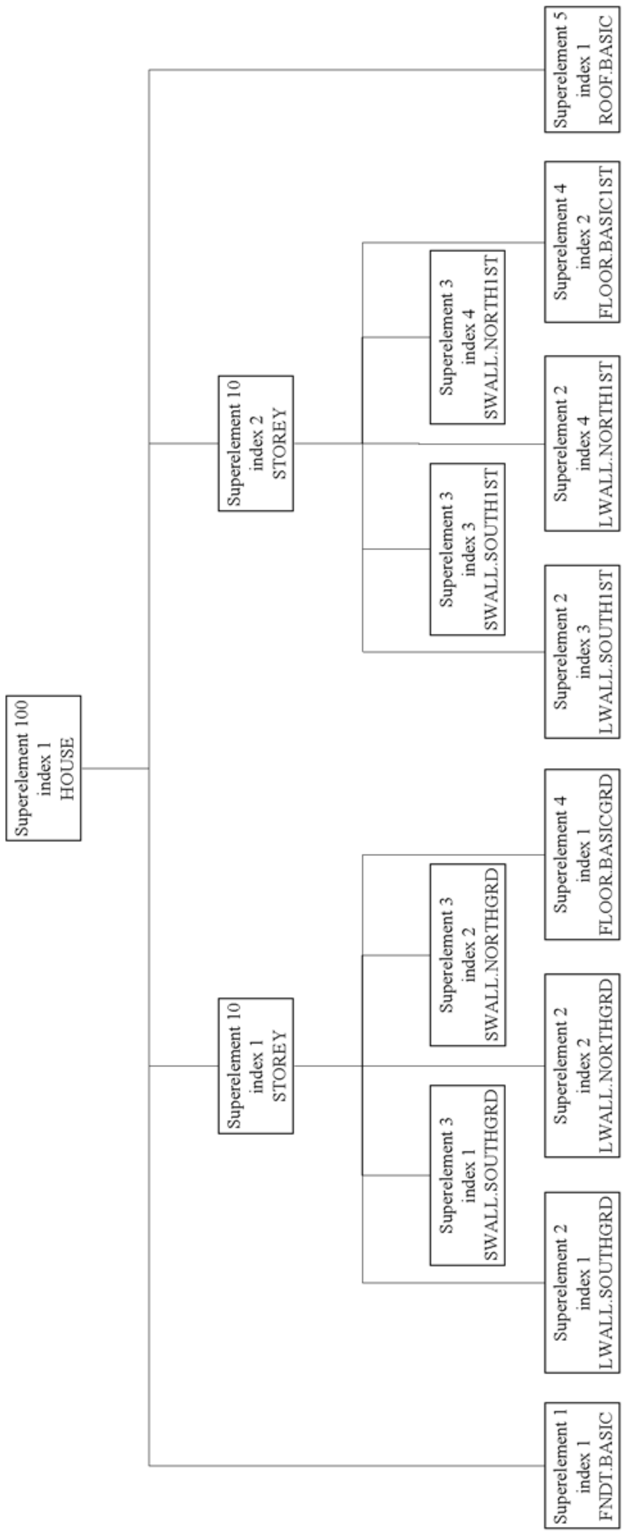


Figure 3.20 Superelement hierarchy for the house model

3.4.3 Tutorial in Using the LOAD ASSEMBLY Command

The tutorial below takes you step-by-step through the commands for assembling the loads for the example of Section 3.4.2. The loads are illustrated in Figure 3.21.

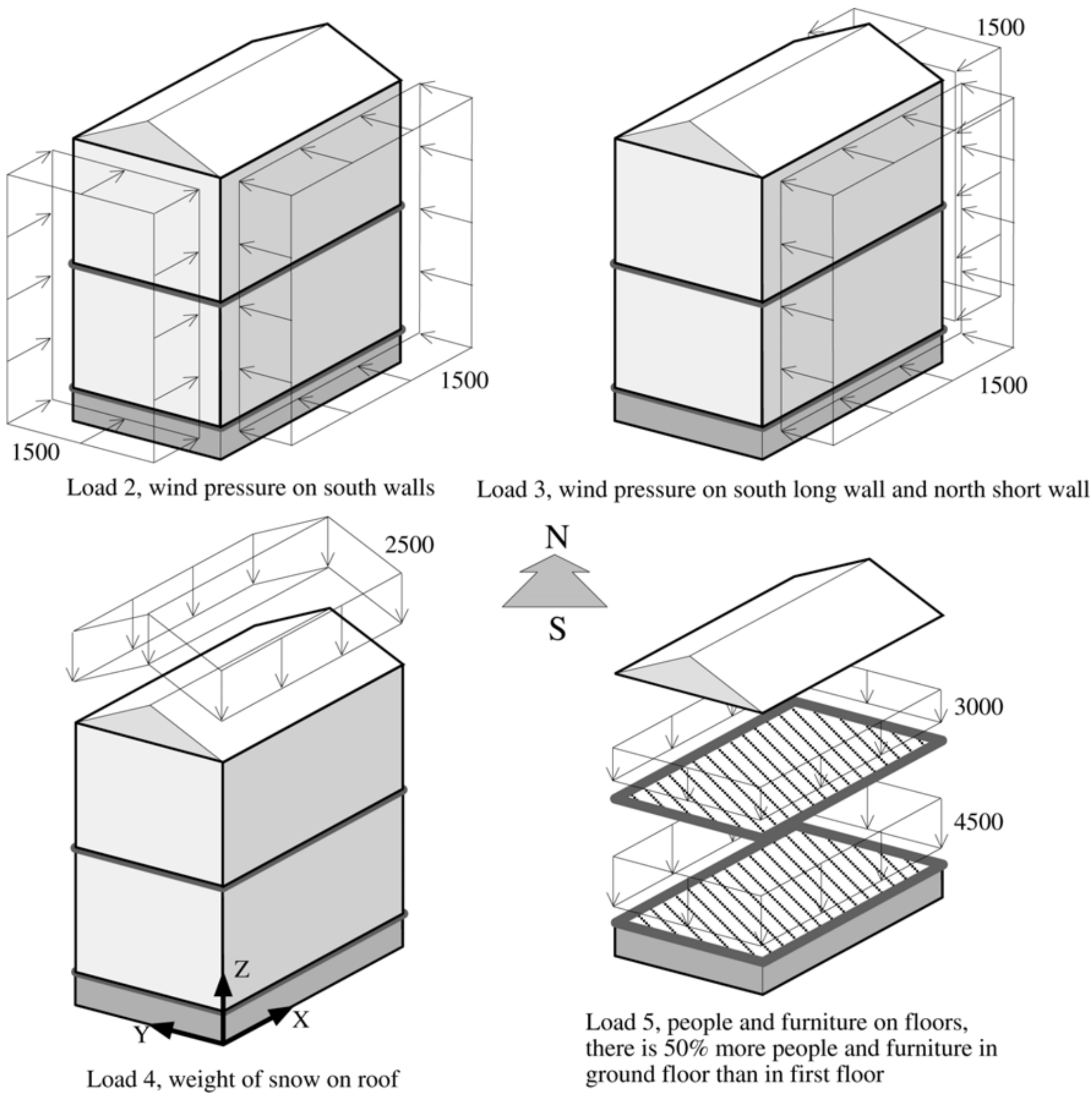


Figure 3.21 Loads on the house model

The five loads to be created for the house are:

Load case 1: Self weight (gravity) of the house

Load case 2: Wind pressure on south walls (both long and short walls)

Load case 3: Wind pressure on south long walls and north short walls

Load case 4: Weight of snow on roof (this is a house in Norway)

Load case 5: Weight of people and furniture on floors

In the input for assembling the loads you refer to a single first level superelement occurrence by giving its name and location string and to several occurrences by using wild-card notation (*):

```
ASSEMBLY OLD 100
LOAD ASSEMBLY
% --- Load 1 is self weight (gravity)
             1 INCLUDE-LOAD *.* 1 1.0
               END
% --- Load 2 is wind pressure on south walls (both long and short walls)
             2 INCLUDE-LOAD *WALL.SOUTH* 2 1.0
               END
% --- Load 3 is wind pressure on south long wall and north short wall
             3 INCLUDE-LOAD LWALL.SOUTH* 2 1.0
               INCLUDE-LOAD SWALL.NORTH* 2 -1.0
               END
% --- Load 4 is weight of snow on roof
             4 INCLUDE-LOAD ROOF.BASIC 2 1.0
               END
% --- Load 5 is weight of people and furniture on floors, there are
%     50% more people and furniture in ground floor than in first floor
             5 INCLUDE-LOAD FLOOR.BASICGRD 2 1.5
               INCLUDE-LOAD FLOOR.BASIC1ST 2 1.0
               END
END END
```

- Global load case 1 (gravity) will include local load case 1 from all (*.*) first level superelements.
- Global load case 2 (wind pressure on south walls) will include local load case 2 from the superelements long and short walls (*WALL), located to the south and including both storeys (SOUTH*).
- Etc.

The command will establish the load combinations required *on all levels from the second level and to the top*. This can be verified by printing the load combinations for the various higher level superelements.

Note: The LOAD ASSEMBLY command will typically create more load combinations for intermediate level superelements (between first and top level) than you normally will create by the more manual one-by-one and group methods. Such extra load combinations for intermediate level superelements will not make any difference except for spending somewhat more computer time and disk space.

Note: In the above example location strings are only given for first level superelements and loads are assembled from first level directly to the top level. You may also assemble loads to intermediate level superelements. You then need to combine loads from these intermediate level superelements to the top by either the assembly or one-by-one method.

3.4.4 Advice on Giving Unique Identifications to Superelement Occurrences

The house example of Section 3.4.2 and Section 3.4.3 illustrates how name and location strings uniquely identify superelement occurrences. The LOCATION CREATE command assigns location strings to first level superelements when these are included into second level. Thereafter the LOCATION USE command modifies these location strings of first level superelements during the assembling of third and higher level superelements. The wild-card notation allows the location strings of several first level superelements to be modified by a single LOCATION USE command by appending characters to the strings.

You need to determine a convention for location strings for your model. You also have to device a scheme for how to arrive at this convention, i.e. how to employ the LOCATION CREATE and LOCATION USE commands during the assembly process. The scheme will depend on how the superelement hierarchy is organised. To be able to determine a practical convention and a scheme you should be familiar with the possibilities and limitations of the LOCATION USE command; see Chapter 5 for this. You may find that assigning name and location strings to your superelement occurrences will influence the organisation of the superelement hierarchy. In the house example of Section 3.4.2 and Section 3.4.3 we were able to merely append characters to the location strings assigned the first time. For example, when the long wall (LWALL) was included in the second level superelement STOREY the first time it was assigned location string SOUTH. Later in the assembly process the location string was merely appended by GRD and 1ST because these occurrences were all located in a southerly direction. This may not always be possible.

Consider the example of Figure 3.22. A single superelement 10 is used nine times to establish the complete model 40 at fourth level. When being included into the second level superelement 20, we may decide to give superelement 10 the location strings A and B. Thereafter we may choose to merely append a character to the location strings each time superelement 10 is repeated by repeating higher level superelements. We will end up with location strings as shown. However, this may not be a very logical convention for location strings.

First level superelement 10 is given name TRIANGLE.

Second level superelement 20 includes 10 twice (first with no translation/rotation, secondly with 180° rotation). Location strings are assigned by:

`LOCATION CREATE A`	for shaded area
`LOCATION CREATE B`	for blank area

Third level superelement 30 includes 20 twice, second inclusion is mirrored about a vertical south-north plane. Location strings are modified by:

`LOCATION USE * *C`	for shaded area
`LOCATION USE * *D`	for blank area

Fourth level superelement 40 includes 30 twice, second inclusion is mirrored about a vertical west-east plane. First level superelement 10 is also included directly. Location strings are modified and created by:

`LOCATION USE * *E`	for shaded area
`LOCATION USE * *F`	for blank area
`LOCATION CREATE G`	for hatched area

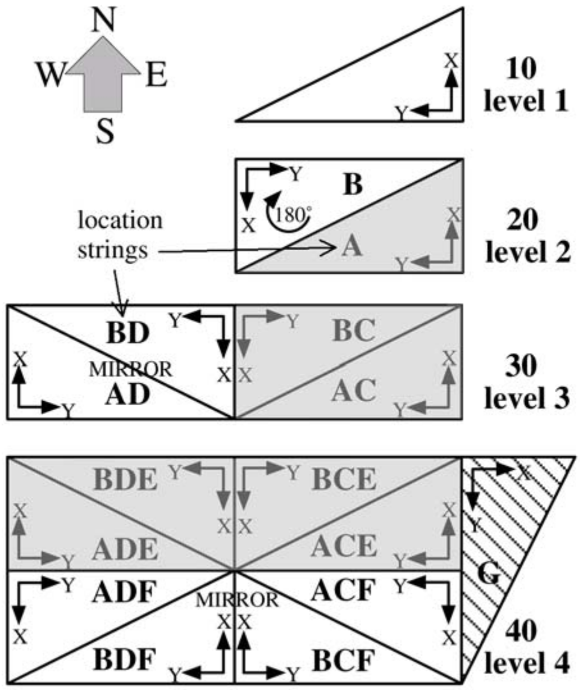


Figure 3.22 Location string convention, alternative 1

Alternatively, we may want location strings reflecting the positions of the superelement occurrences relative to the north, west, south and east directions. EN means east-north, NE means north-east, NW means north-west, etc. Figure 3.23 shows a scheme arriving at this more logical convention for location strings.

First level superelement 10 is given name TRIANGLE.

Second level superelement 20 includes 10 twice (first with no translation/rotation, secondly with 180° rotation). Location strings are assigned by:

```
LOCATION CREATE A       for shaded area
LOCATION CREATE B       for blank area
```

Third level superelement 30 includes 20 twice, second inclusion is mirrored about a vertical south-north plane. Location strings are modified by:

```
LOCATION USE A EN  }
LOCATION USE B NE  }  for shaded area
LOCATION USE A WN  }
LOCATION USE B NW  }  for blank area
```

Fourth level superelement 40 includes 30 twice, second inclusion is mirrored about a vertical west-east plane. First level superelement 10 is also included directly. Location strings are modified and created by:

```
                        no modifications for
                        shaded area!
LOCATION USE *N *S }
LOCATION USE N* S* }    for blank area
LOCATION CREATE EE      for hatched area
```

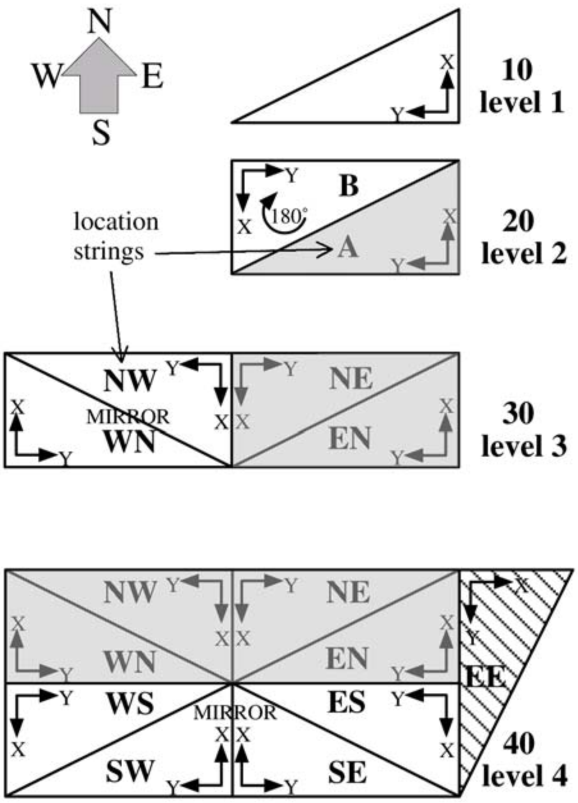


Figure 3.23 Location string convention, alternative 2

Note: If you are unable to device an easy scheme for arriving at the chosen convention for naming location strings you may always resort to the scheme shown in Figure 3.22 up to the top level and for the top level substitute the location strings with the proper ones. See Figure 3.24.

To get this third level superelement, see alternative 1 above.

Fourth level superelement 40 includes 30 twice, second inclusion is mirrored about a vertical west-east plane. First level superelement 10 is also included directly. Location strings are modified and created by:

```
LOCATION USE AC EN
LOCATION USE BC NE    for shaded area
LOCATION USE BD NW
LOCATION USE AD WN
LOCATION USE AC ES
LOCATION USE BC SE    for blank area
LOCATION USE BD SW
LOCATION USE AD WS
LOCATION CREATE EE    for hatched area
```

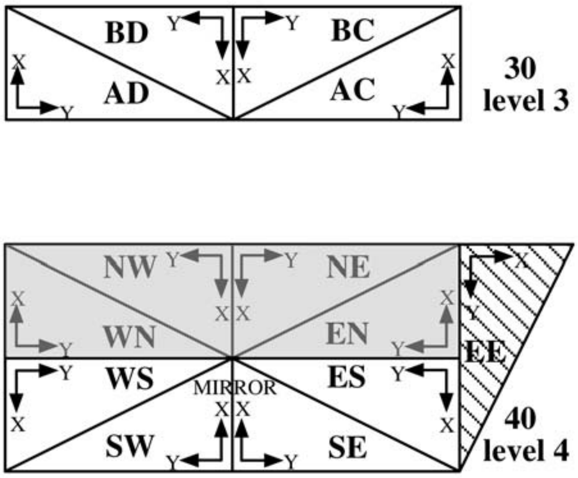


Figure 3.24 Location string convention, alternative 3

3.5 Boundary Conditions

Boundary conditions are defined for the six degrees of freedom (d.o.f.s) of a node individually. Using the BOUNDARY command you can define the following boundary conditions:

- Free — the d.o.f. is free to displace, this is the default boundary condition for all d.o.f.s of all nodes
- Fixed — the d.o.f. is fixed at zero displacement
- Prescribed — the d.o.f. is fixed at a given displacement given by the LOAD NODE command
- Super

A superelement can only be included in a superelement assembly if one or more of its nodes (or d.o.f.s) are defined as super. If one or more of the nodes (d.o.f.s) of a superelement are super the superelement cannot be the top level superelement (the complete model). It must be included in a higher level assembly.

In the BOUNDARY command you need to select nodes. This may be done inside the BOUNDARY command by the SELECT option. Or you may pre-select the relevant nodes by the TAG command in which case you refer to these pre-selected nodes by the TAGGED option inside the BOUNDARY command. (TAGGED is in effect a set with pre-defined name, you may also use the SET command to define sets.) In either case you need to select nodes using the node select features described in Section 5.1.

As explained in Section 5.1, alternatively to selecting nodes directly by giving their triplets you may select a line, plane or volume through or enclosing the desired nodes. And these lines, planes and volumes may be defined referring to nodes or to coordinates. Moreover, the coordinates may be given in the cartesian system or in a pre-defined cylindrical system.

For example, if you want to select all nodes in a plane you may find that the so-called 2-PLANE option and giving two sets of cartesian coordinates is the quickest alternative. First give a point in the plane and then a point defining together with the first point a normal to the plane. All nodes on a cylindrical surface are easily

selected by the 2-PLANE option referring to a cylindrical system; the first point is positioned in the desired cylindrical plane and the second point on a line through the first point and normal to the cylindrical axis.

By default the boundary conditions given refer to the global cartesian system. Alternatively, you may give the boundary conditions in a pre-defined cylindrical system (defined by the COORDINATE-SYSTEM command) or with pre-defined transformations (a cartesian system with rotation compared to the global system defined by the TRANSFORMATION command). This may for example be used to introduce a sloping slip surface: rotate to a system having one of its axes normal to the slip surface and fix the translational d.o.f. corresponding to this axis while letting the other two translational d.o.f.s be free.

3.6 Linear Dependency

The LINEAR-DEPENDENCY command offers two alternative types of linear dependency:

- General node dependency
- Two node dependency

Using the ‘general node dependency’ any d.o.f. of a node may be made linearly dependent on any other d.o.f.s of any other nodes. The user explicitly specifies the linear dependency factor for all the independent d.o.f.s. The displacement of the dependent d.o.f. will then be:

$$r_d = r_{i1} \cdot \beta_1 + r_{i2} \cdot \beta_2 + r_{i3} \cdot \beta_3 + \dots$$

where r represents the displacements, subscripts d and i represent the dependent and independent d.o.f.s respectively, and β is the given dependency factors.

With the ‘two node dependency’ *all* d.o.f.s of a given node are made linearly dependent on the corresponding d.o.f.s of *two* other nodes. The displacement of the dependent d.o.f.s will be:

$$r_d = r_{i1} \cdot \beta + r_{i2} \cdot (1 - \beta)$$

where β is a dependency factor given by the user. Presel will compute a default value for β as explained in Figure 3.25. β is computed based on the projection of the dependent node onto the line between the two independent nodes.

Normally, the ‘two node dependency’ has physical meaning only when the dependent and the two independent nodes all lie on a straight line.

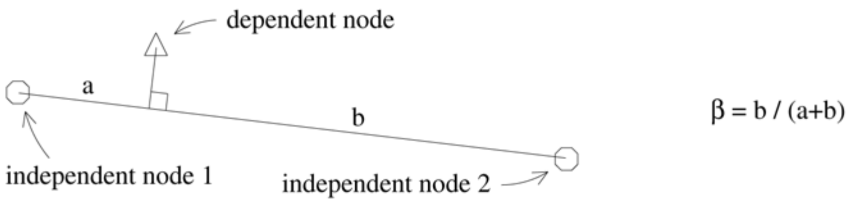


Figure 3.25 Two node linear dependency — the dependency factor ß

Note: Dependent nodes are indicated by blue triangles in the model display.

Note: Independent nodes = supernodes are indicated by blue octagons (will look like circles).

All independent d.o.f.s must be super d.o.f.s, i.e. they are defined with boundary condition code ‘super’ using the BOUNDARY command prior to giving the LINEAR-DEPENDENCY command. The ‘two node dependency’ alternative also allows the user to define the independent nodes as super *within* the command by the FORCE-INTO-SUPER alternative. This implies that introducing linear dependency for a superelement involves that the superelement must be included in yet a higher level superelement.

The requirement that the independent d.o.f.s must be super only concerns second and higher level superelements as created by Presel. In the case of first level superelements created by Preframe and Prefem the independent d.o.f.s need not be super provided that the Multifront equation solver is used in Sestra.

Linear dependencies in a transformed coordinate system may be specified by first assigning a transformation to the dependent and independent nodes using the BOUNDARY command.

3.7 Sets

The command TAG may be used to define a set of nodes that may be referred to by the option TAGGED in, for example, the BOUNDARY command; see Section 3.5. In effect, this is therefore a set of nodes with the pre-defined name TAGGED. When you create a new higher level superelement (by the ASSEMBLY NEW command) the set TAGGED is empty until you put nodes into it. The set will not be changed by moving between the superelements (by the ASSEMBLY OLD command) or by exiting and re-entering Presel. You may refer to the complementary set of nodes by the pre-defined name UNTAGGED. The command UNTAG is used to remove nodes from the set TAGGED.

In addition to the set TAGGED you may define any number of named sets of nodes by the DEFINE SET command. The standard set operators UNION-WITH, SUBTRACT-BY and INTERSECTION-WITH are used to define the sets.

A set that contains supernodes will be available also within an assembly into which the superelement is included. This is provided that the set was defined prior to including the superelement. A set containing supernodes defined for a first level superelement (in Prefem and Preframe) will also be available in assemblies. Note that if a set contains both supernodes and other (free or fixed) nodes then the set at assembly level will only contain the supernodes (and these will be free nodes at assembly level).

Moreover, if any of the nodes of the set are given the boundary condition super (re-defined as supernodes) for the superelement assembly then the set, containing these nodes, will be available for yet a higher level superelement assembly.

Finally, if two or more superelements have sets of supernodes with the same name then these will be merged at assembly level.

Note: Sets defined in Prefem or Preframe containing only elements or geometry (Prefem only) will not be available in Presel as only nodes are relevant here.

Note: The transfer and merging of sets of supernodes from superelements to superelement assemblies is only avaialble for named sets and not the predefined set TAGGED (and UNTAGGED).

3.8 Display and Print

The DISPLAY CURRENT-SUPERELEMENT command will display the current superelement. This display may be refined by the SET GRAPHICS HIDDEN command plus two options under the SET GRAPHICS PRESENTATION command: FILLED-ELEMENT and COLOUR-SUPERELEMENTS. All these three display modes may be used simultaneously. Figure 3.26 shows an example of a display using the hidden option.

In addition to displaying the current superelement any superelement may be displayed without changing current superelement by the DISPLAY SPECIFIED-SUPERELEMENT command. This command is practical when you are working with assembling superelements in an assembly and only want to make a quick check of the appearance of a certain superelement.

Furthermore, the DISPLAY LOCATE-SUPERELEMENT command allows highlighting (by a different colour) a given first level superelement in an assembly.

Note: There are shortcut command buttons under the headings 'DispMod' and 'Display' for all display alternatives explained above.

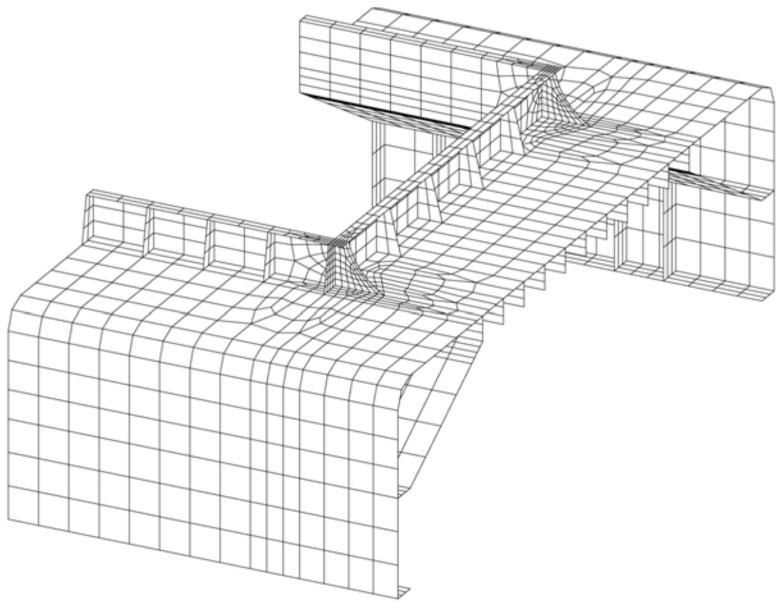


Figure 3.26 Display of a superelement using the hidden option

The LABEL command may be used to add information to the displayed superelement.

You may also use the DISPLAY option during the inclusion of a superelement to see the current position of the superelement being included, i.e. to check its position before you complete the inclusion. The tutorial of Section 3.2.2 illustrates this and the description of the INCLUDE supno DISPLAY command in Chapter 5 shows an example. This display cannot be annotated by the LABEL command.

You may also verify the load combinations for an assembly using the DISPLAY LOAD command. There are two ways of doing this:

- You may determine how many load cases each included superelement contributes with to a given load combination. This is available through the DISPLAY LOAD LOADED-SUPERELEMENT command. Colour coding of the superelements indicates which of them contribute with no load cases, which contribute with one, which contribute with two, and so on.

- You may determine which load cases with what factor each included superelement contributes with to a given load combination. This is available through the two commands DISPLAY LOAD FIRST-CONTRIBUTING-LOAD and DISPLAY LOAD NEXT-CONTRIBUTING-LOAD. The FIRST-CONTRIBUTING-LOAD option colour codes superelements contributing with their load case number ‘i’ where ‘i’ is the lowest contributing load case number over all superelements. Thereafter you should use the NEXT-CONTRIBUTING-LOAD option which colour codes superelements contributing with their load case number ‘j’ where ‘j’ is the second lowest contributing load case number. Repeating the NEXT-CONTRIBUTING-LOAD option will loop through all contributing load cases. The load factors are for each display printed on top of the colour coded superelements.

Note: The loads values defined in Prefem/Preframe and computed in Wajac/Wadam cannot be displayed in Presel as it has no knowledge of the contents of these loads.

In addition to displaying the model the PRINT command is useful for verification purposes. Various PRINT commands are exemplified in Figure 3.27, Figure 3.28, Figure 3.29, Figure 3.30 and Figure 3.31.

```
  SUPER EL.
  TYPE          LEVEL      NODES      ELEMENTS   LOADCASES
  ---------   ---------  ---------  ---------  ---------
          1           1        295        304          3
          2           1        826        857          1
          3           1        319        310          0
         10           2        110          3          3
++      100           3         29          2          3
```

The `++' identifies the current superelement.

This is the level of the superelement.

For first level superelements this is number of basic elements, for higher level superelements this is number of included superelements.

Figure 3.27 PRINT OVERVIEW-OF-SUPER-ELEMENTS

```
                       BANDW.             STIFF. MATRIX REDUCTION BY SESTRA:
  SUPER EL.   FREE     FREE     SUPER     MFLOP         on 10MFLOP/s   per loadcase
  TYPE        D.O.F.S  D.O.F.S  D.O.F.S   ESTIMATE      DDD:HH:MM:SS   DDD:HH:MM:SS
  ---------   -------- -------- --------  ----------    ------------   ------------
          1      1446      185      306     286.224      0  0  0 28     0  0  0  0
          2      4062      371      396    2070.386      0  0  3 27     0  0  0  1
          3      1236      167      498     398.084      0  0  0 39     0  0  0  0
         10       486      485      174      66.398      0  0  0  6     0  0  0  0
++      100       174      173        0       1.317      0  0  0  0     0  0  0  0
  TOTAL          7404     1381     1374    2822.410      0  0  4 42
```

The `++' identifies the current superelement.

MFLOP is the number of millions of floating point operations (real number additions, multiplications, etc.)

Here is given in days, hours, minutes and seconds the estimated reduction time per superelement for a processor performing 10 MFLOP per second.

Figure 3.28 PRINT CPU-TIME-ESTIMATES-IN-REDUCTION

Table shows superelements included in this superelement assembly.

```
SUPER ELEMENT TYPE:       100  LEVEL:        3

SUP.EL SUP.EL        MIR         ROTATE                         ORIGIN
TYPE   INDEX  LEVEL  X-Y    X      Y      Z         X          Y          Z
------ ------ ------ --- ------ ------ ------ ---------- ---------- ----------
    10      1      2  NO    0.0    0.0    0.0      0.000      0.000      0.000
    10      2      2 YES  180.0    0.0    0.0      0.000      0.000      0.000
```

Figure 3.29 PRINT ELEMENT tabulates information on included superelements

```
                   SUPER ELEMENT LEVEL
                        4          3             2             1
                   ------ROOT---------1:100.1----------1:10.1-----------1:1.1
                                                 !             !
                                                 !             !-----2:2.1
                                                 !             !
                                                 !             !-----3:3.1
                                                 !
                                                 !----2:10.2-----------1:1.2
                                                               !
                                                               !-----2:2.2
                                                               !
                                                               !-----3:3.2
```

PRINT SUPER-ELEMENT-HIERARCHY 0 1 (see the explanation of the command in section 5) ties yet unconnected superelement hierarchies together in `ROOT'.

PRINT SUPER-ELEMENT-HIERARCHY 100 1 tabulates only the hierarchy including and below superelement 100.

branch number
superelement number
superelement index

Figure 3.30 PRINT SUPER-ELEMENT-HIERARCHY

Table shows coordinates for this superelement.

```
SUPER ELEMENT TYPE:       10  LEVEL:       2

SUP.EL  SUP.EL  EXT.    INT.                   C O O R D I N A T E S           BOU
TYPE    INDEX   NO.     NO.            X                Y                Z      /ND
------- ------- ------- ------- -------------- -------------- -------------- --
     1       1      17      45    9840.000000        0.000000        0.000000 X6
     3       1       1      45
     1       1      18      46    9840.000000        0.000000      616.666687 X6
     1       1      37      47   10840.000000    -1680.000000        0.000000  6
     3       1       5      47
     1       1      19      48    9840.000000        0.000000     1233.333374 X6
     1       1      20      49    9840.000000        0.000000     1850.000000 X6
```

If a node has more than one triplet all will be listed.
This node has two triplets,
this node has one.

BOU means boundary conditions, ND means number of d.o.f.s. X means the node has a boundary condition, use PRINT NODE BOUNDARY-CONDITIONS for details. 6 means this node has 6 d.o.f.s.

The INT.NO. (PRESEL's internal node number) is normally of little interest.

Figure 3.31 PRINT NODE COORDINATES

3.9 Practical and Efficient Application of the Superelement Technique

The theoretical foundation for the superelement technique puts few, if any, limitations on how to split the structure into superelements and how to put these together to form the complete model. However, the numerical accuracy of the results and above all the consumption of computational time and disk space are influenced by such choices.

There are several aspects of how to apply the superelement technique in an optimal way and an in-depth discussion cannot be provided here. Efficient application of the technique rely on a combination of an understanding of the theoretical foundation, consideration of the hardware being used and practical experience.

Discussing with experienced users and taking heed of the following advice will enable you to take advantage of the superelement technique in an efficient way while building up your own practical experience. Some of the items below contradict each other to some extent, this only underlines the fact that you often have to balance between conflicting considerations. Also see Figure 3.32 for illustrations of some of the items below.

- How to split the structure into superelements?
  - — Utilise the possibility to repeat superelements. Both first and higher level superelements may be repeated. Repetition is possible whenever two or more parts of the structure are geometrically equal. Remember that superelements may also be mirrored.
  - — Make first level superelements as large as possible, limited though by the capacity of your computer.
  - — The two items above combined implies that there is a limit to how small the superelements should be to enable repetition before the gain is outweighed by loss in other ways, e.g. administration of many superelements and heavy higher level superelements.

— Very small superelements will often be a disadvantage in the postprocessing.

— The ratio between supernodes and internal (free) nodes should be as small as possible. In practical terms this may be seen as making the superelements as compact in shape as possible.

- How to assemble the superelements to form the complete model (some of the advice below will have bearing on how to split the structure into superelements)?

  — Limit the number of higher level superelements and the number of levels. Few and moderately large higher level superelements are better than many smaller ones. For a large model this implies that the second level superelements will include many first level superelements, the third level superelements will include many second level superelements, and so on.

  — Be aware of that reduction of higher level superelements is time consuming. A higher level superelement will normally be much more time consuming than a first level superelement with the same number of internal and super nodes. This is because the stiffness matrix of a higher level superelement has few zeros and a large bandwidth.

  — Assemble superelements in an order corresponding to their topological sequence and not in a haphazard way. (Assemble superelements in the way Lego bricks are put together.)

  — Avoid coupling one superelement with many other superelements.

  — Do not assemble superelements not geometrically coupled. This concerns superelements belonging to the same structure, i.e. their stiffnesses are coupled through other superelements. On the other hand, if you want to analyse several non-coupled models — for example to test various meshes or designs for the same structure — you may find it convenient to make a single model comprised of non-coupled superelements and analyse all these in one operation (one Sestra run). (This approach should not be employed for large models.)

- You also need to consider which load cases to create for the first level superelements and how to combine these through the higher level superelements to create the final loads for the top level superelement.

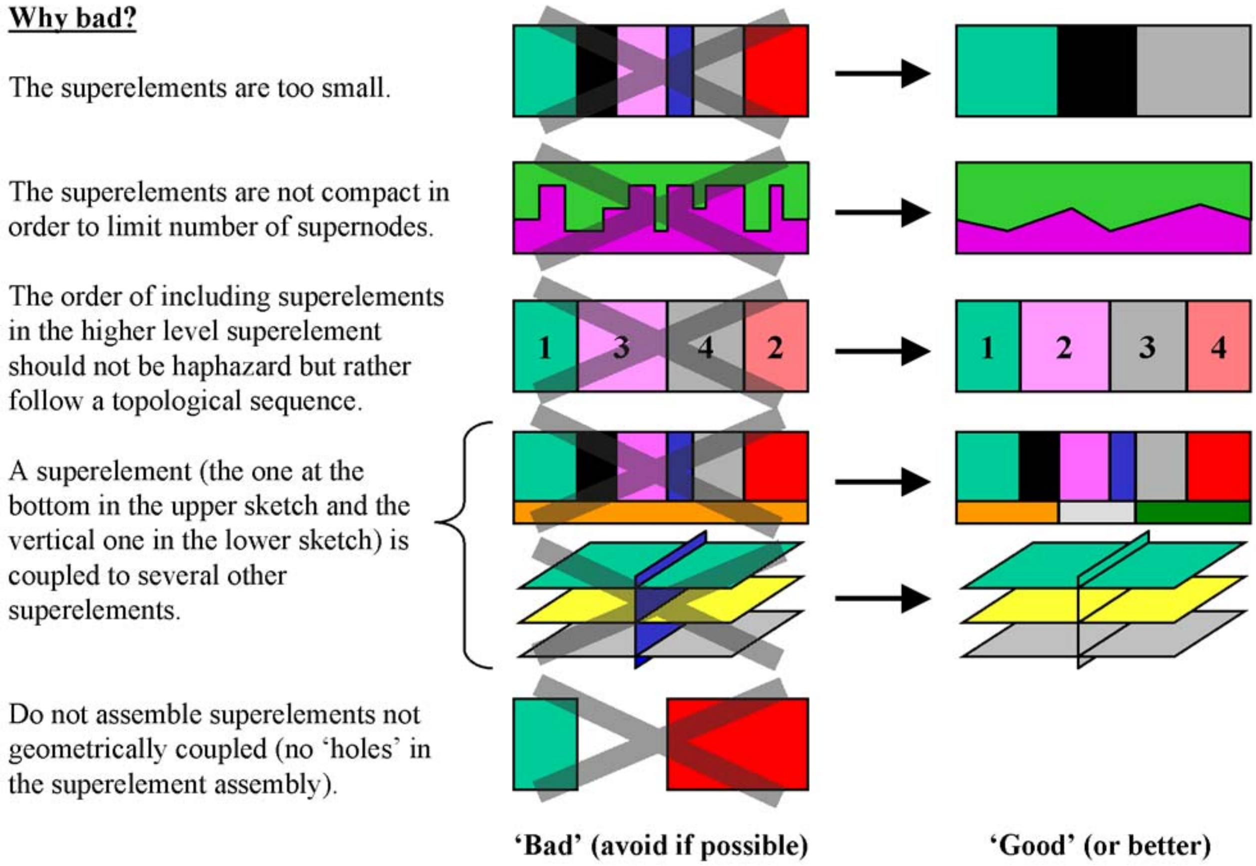


Figure 3.32 'Good' and 'bad' superelements

3.10 Node Numbering Optimization to Minimise the Bandwidth

Sestra offers two equation solvers, the traditional Supermatrix solver and the Multifront solver, a more recent and highly efficient solver. The Multifront solver is not influenced by whether the node numbering has been optimised to reduce the bandwidth of the stiffness matrix.

For the traditional Supermatrix solver, however, it is absolutely essential to minimise the bandwidth of the first level superelements' stiffness matrices by optimising or re-numbering their *internal* node numbering. The auxiliary program Bpopt is used for this purpose (in the case of Preframe the optimization is normally done inside the program). When using the SESAM Manager optimization of first level superelements is controlled by Manager.

Note: The optimization should be performed prior to reading the superelements into Presel.

Optimising higher level superelements may be done inside Presel using the command OPTIMIZE. Note that a higher level superelement can only be optimised when it is complete, i.e. when all relevant superelements have been included into it and before it is included in new higher level superelements. The *top* level superelement may, however, be optimised after concluding the Presel session using the auxiliary program Bpopt.

Provided the superelements are assembled into a higher level superelement (an assembly) in a logical brick-on-brick way as advised in Section 3.9 there is very little, if anything, to gain in terms of CPU reduction by optimising higher level superelements. Using the OPTIMIZE command is therefore normally not necessary. See Section 3.9 on practical and efficient use of the superelement technique.

On the other hand, if a higher level superelement is created by assembling superelements in a haphazard way (in effect, this is the way the automatic assembling of superelements in Pretube works) optimising the higher level superelements may be important.

4 EXECUTION OF PRESEL

This section provides information on:

- How to start Presel
- Line-mode input syntax
- Files used
- Creating plots for reports
- Alternative execution modes
- Program requirements
- Program limitations

4.1 Program Environment

Presel is available on Microsoft Windows.

4.1.1 Starting Presel from Manager

Presel is started from Manager by first setting the type of analysis to be superelement analysis, click **Options | Superelement**, and then clicking **Model | Superelement handling Presel**. The graphical user interface of Presel is explained in Section 3.1.

4.1.2 Line-Mode Input of Commands and Arguments

The syntax and characteristics of line-mode input are as follows:

- The parameters (commands, sub-commands and data) are separated by one or more blank characters (or a comma) and may be entered one by one or with two or more entries on a single line of input. For example:

  ```
  COMMAND
  SUB-COMMAND
  SUB-SUB-COMMAND
  data ...
  ```

  is equivalent to:

  ```
  COMMAND SUB-COMMAND SUB-SUB-COMMAND data ...
  ```

  Note, however, that data belonging to different data sets cannot be entered on a single line.

- UPPER CASE = lower case (all commands will be logged on a ‘command log file’ in UPPER case).

- Commands and sub-commands may be abbreviated as long as they are unique. In a command consisting of words separated by hyphens, each word may be abbreviated or completely left out. Examples:

  ```
  NODE-NUMBERS = N-N
  COMMAND-INPUT-FILE = C-I
  ```

- Default values are provided between slashes, ‘/default/’. The defaults are accepted by hitting Return.

- Real or integer input may be entered irrespective of type of numerical data, use ‘E’ for exponent.

- ‘?’ will list all legal commands and data options. (This command is irrelevant for the graphical user interface where all legal commands and data options are at any time given in the command column of the graphic-mode window.)

- ‘P?’ will list all legal commands starting with P.

- ‘..’ (two dots) will execute the input data before ‘..’ and subsequently abort the current command. The program is thereafter ready for more commands. If the data before the ‘..’ is incomplete it will be discarded.

- ‘,,’ (two commas) will cause one default parameter to be accepted. (May be useful when editing a ‘command input file’.)

- ‘;’ (semicolon) will cause default parameters to be accepted until the end of the parameter group or until there is no default provided.

- Text containing blank characters has to be enclosed within single quotes: 'this is a text'.

- ‘%’ (percentage sign) at the beginning of a line is used for entering a comment. Comments will be logged together with commands on the ‘command log file’ (see Section 4.1.3). Note that the program will occasionally log information on the ‘command log file’, this will appear as comments in between data and comments entered by the user. The program information is preceded by ‘%%’ (two percentage signs) to distinguish it from the user’s own comments. This makes it easy to strip a ‘command log file’ for program information in connection with creating a ‘command input file’ (any fairly good editor will have a macro-functionality or similar enabling you to locate and remove all lines with ‘%%’). Moreover, comments preceded by ‘%%’ will *not* be logged on the ‘command log file’ to avoid irrelevant logging of program information when using an unedited ‘command log file’ as a ‘command input file’.

4.1.3 Files used by Presel

The file environment of Presel is illustrated in Figure 4.1. The file extensions (.MOD, .JNL, etc.) are given together with file descriptions.

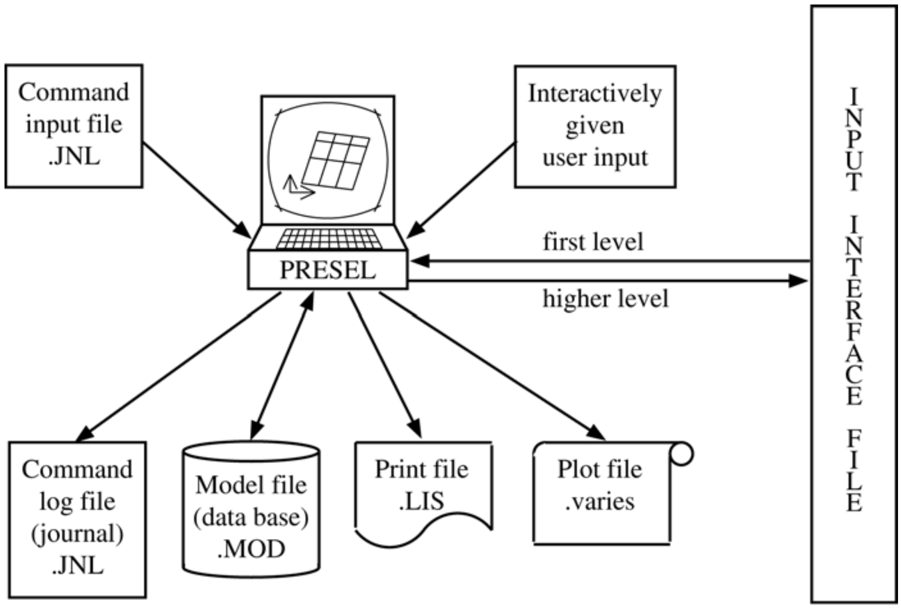


Figure 4.1 The file environment of Presel

The files are:

- The ‘command log (journal) file’ (.JNL) is an ASCII file on which all commands and data given to the program are logged. This means that both data typed (or clicked) by the user and data read by the program from a ‘command input file’ will be logged. However, commands not changing the model (and data base), e.g. a command displaying data, will not be logged. The time of opening and closing the ‘model file’ is also logged. The file is very useful as a backup file both for verification purposes and for later use as a ‘command input file’. The ‘command log file’ can be read and modified by a text editor.

- The ‘command input file’ (.JNL) is an ASCII file which may be read into the program. The commands contained on this file will have the same effect as if they where given by the user directly. The file is processed by using the command ‘SET COMMAND-INPUT-FILE ...’ followed by ‘# ALL’ (the latter command means: read all commands found on the file). Alternatively, you may specify a ‘command input file’ when starting Presel from Manager.

- The ‘model file’ (.MOD) is the binary data base containing all model data. The file cannot be read by a text editor.

- The ‘print file’ (.LIS) is an ASCII file which contains tables over data requested for printing by the PRINT command.

- The ‘plot file’ contains graphic information produced by the PLOT command. The file extension will depend on the plot format chosen (see the SET PLOT FORMAT command). See Section 4.1.4 for advice on using the CGM format to include plots in reports.
- The ‘Input Interface File’ (.FEM) — termed T-files for short — is comprised of:

  — First level superelements (created by Prefem or Preframe) which are read by Presel, and

  — Higher level superelements which are written by Presel.

Presel has been designed to protect the user against loss of valuable data. However, accidental loss of data may occur. This may be caused by the user by for example inadvertently deleting the ‘model file’ or it may be due to an inconsistency in the data model. Such inconsistency may occur for several reasons:

- The computer goes down.
- The disk is full, the disk quota is exhausted or user privileges are inadequate.
- There is an error in the program.

If Presel discovers an inconsistency in the data model the program will normally close all files opened and abort the execution. Presel may then be restarted using the ‘model file’. In some cases, however, it will not be possible to resume normal execution due to an irrecoverable inconsistency.

If the ‘model file’ is lost it can be reconstructed by re-executing the program and reading input from the ‘command log file’, i.e. using it as a ‘command input file’.

Note: The ‘model file’ will normally not be compatible between different versions of Presel. The ‘command log file’ may, however, be used as input to a new version.

4.1.4 Creating Plots for Reports

The CGM plot format (see the SET PLOT FORMAT command) is well suited for importing SESAM plots into reports produced by MS Word and other word processors. You may also transfer CGM files from one operating system to another, just make sure to use the ‘binary’ option when transferring the file with FTP (or another protocol).

Depending on the capabilities of your word processor the PostScript plot format may also be used for the purpose of importing SESAM plots into reports. Contrary to CGM, PostScript is an ASCII formatted file and is therefore more easily transferred from one computer make to another.

Note that a word processor will normally recognise only one picture (display) on each file. You should, therefore, specify a new file name for each plot command using the SET PLOT FILE command.

4.1.5 Command Line Arguments

It is possible to specify command line arguments when starting Presel. A command line argument will influence the program execution in various ways.

The command line arguments are:

/PREFIX=text	General file name prefix

/NAME=text	General file name
/STATUS=text	Data base / journal file status
/INTERFACE=*LINE*	Start the program in line-mode.
/INTERFACE=PICK	Start the program in graphical user interface mode.
/HEADER=NONE	Do not show the program header.
/NOHEADER	Do not show the program header.
/HEADER=*SHORT*	Show the standard program header.
/WRITE-SUPERELEMENT=number	Write an Input Interface File with the given (top level) superelement number (plus all lower level superelements) when exiting the program.
/*NOWRITE-SUPERELEMENT*	Do not write an Input Interface File.
/COMMAND-FILE=filename	Read the specified command input file after the model/journal file has been accepted.
/*NOCOMMAND-FILE*	Do not read a command input file.
/FORCED-EXIT	Force EXIT after initialisation and after processing of the file defined by the /COMMAND-FILE argument.
/*NOFORCED-EXIT*	Disable FORCED-EXIT.
/EYEDIR-X=value	Set initial eye direction X-value.
/EYEDIR-Y=value	Set initial eye direction Y-value.
/EYEDIR-Z=value	Set initial eye direction Z-value.
/WINDOW-SIZE=value	Set height of the graphic-mode window (width is determined based on height). The value 100 corresponds to full height of the screen. Default value is 90.

Note the following about how to enter the command line arguments:

- Command line arguments and values can be abbreviated.
- Each argument name must begin with a slash (/) and each argument value must be preceded by an equal sign (=). Spaces can freely be distributed around the equal sign and before each slash.
- Texts with blank spaces and special characters (e.g. file names) must be enclosed in quotes. Note that some operating systems change the case of the input text if it is not enclosed in quotes.
- Slanted arguments or values indicate that these are defaults.

- If at least one of the arguments /PREFIX, /NAME and /STATUS is specified then the prompt for data base and journal file name is skipped and defaults are used for any unspecified values.
- The values given to the /EYEDIR are real values. The default is the Presel default values. If one of the three are given the other two are set to 0.0 unless specified.
- In some cases a virtual screen larger than the real screen is used. In such cases reduce the /WINDOW-SIZE argument value.

4.2 Program Requirements

4.2.1 Execution Time

The execution time required is negligible for most commands. A few commands, however, will require some CPU and should be used with care on low capacity computers. An example of this is a display with hidden option.

4.2.2 Storage Space

The initial size of the data base (prior to any modelling) is less than 2 MB. 10-20 MB will be sufficient for most models.

4.3 Program Limitations

Graphics Devices

The graphical user interface is implemented on Microsoft Windows. Other devices are currently not used.

Memory

Presel allocates memory buffers for access to data of the data base file. When using the graphical user interface Presel will allocate memory for the display.

- **File access buffer**

  The memory is allocated when Presel is started and the amount is fixed until exiting the program. The amount of memory allocated can be changed by editing the configuration (password) file. To change the amount insert (or modify) the line:

  ```
  MSIZE-PRESEL-BUFFER buffer-bytes
  ```

  where buffer-bytes represents the amount of memory Presel will allocate in bytes. The default value is 2457600 (2.4576 millions) representing 150 buffers of 16384 bytes each. The buffer should be changed if, for example, there is not enough memory to use the graphical user interface. Note, however, that increasing the memory for buffers will not improve performance much.

- **Working array for node number optimization**

You may limit the size of the working array used for optimising the node numbering of a higher level superelement by defining the parameter MSIZE-PRESEL-OPTIMIZE in the configuration (password) file. If you do not give any value for this parameter then as much memory as needed will be allocated.

- **Memory for graphical user interface**

  The graphic-mode window will use memory and allocate it when needed. Large displays will need more memory than small displays.

Typing

While typing a command using the keyboard you cannot click commands in menus or select nodes by clicking or use the mouse in any other way until the Return key has been hit or until the typed text has been deleted by backspace.

5 COMMAND DESCRIPTION

The hierarchical structure of the commands and numerical data is documented in this chapter by use of tables. How to interpret these tables is explained below. Examples are used to illustrate how the command structure may diverge into multiple choices and converge to a single choice.

In the example below command A is followed by either of the commands B and C. Thereafter command D is given. Legal alternatives are, therefore, A B D and A C D.

<table>
<tr><td rowspan="2">A</td><td>B</td><td rowspan="2">D</td></tr>
<tr><td>C</td></tr>
</table>

In the example below command A is followed by three selections of either of commands B and C as indicated by *3. For example: A B B B, or: A B B C, or A C B C, etc.

<table>
<tr><td rowspan="2">A</td><td>B</td><td rowspan="2">*3</td></tr>
<tr><td>C</td></tr>
</table>

In the example below the three dots in the left-most column indicate that the command sequence is a continuation of a preceding command sequence. The single asterisk indicate that B and C may be given any number of times. Conclude this sequence by the command END. The three dots in the right-most column indicate that the command sequence is to be continued by another command sequence.

<table>
<tr><td rowspan="3">...</td><td rowspan="3">A</td><td>B</td><td rowspan="2">*</td><td rowspan="3">...</td></tr>
<tr><td>C</td></tr>
<tr><td colspan="2">END</td></tr>
</table>

In the example below command A is followed by any number of repetitions of either of the sequences B D and C D. Note that a pair of braces ({ }) is used here merely to define a sequence that may be repeated. The braces are not commands themselves.

<table>
<tr><td rowspan="2">A</td><td rowspan="2">{</td><td>B</td><td rowspan="2">D</td><td rowspan="2">}*</td></tr>
<tr><td>C</td></tr>
</table>

The characters A, B, C and D in the examples above represent parameters being COMMANDS (written in upper case) and numbers (written in lower case). All numbers may be entered as real or integer values. Brackets ([ ]) are used to enclose optional parameters.

Note: The command END is generally used to end repetitive entering of data. Using double dot (..) rather than END to terminate a command will, depending on at which level in the command it is given, save or discard the data entered. Generally, if the data entered up to the double dot is complete and self-contained the double dot will save the data. If in doubt, it is always safest to leave a command by entering the required number of END commands.

5.1 Node Select Features

Selection of nodes is required in several commands, e.g. in the BOUNDARY and TAG commands. Nodes may be selected by line-mode commands as well as by graphical means.

5.1.1 Line-mode Selection

You may by line-mode commands select:

- Several nodes by referring to their node number triplets and enclosing them in parentheses.
- A SINGLE node by referring to its node number triplet. This option is less relevant after introduction of the previous option of enclosing node number triplets in parentheses.
- A GROUP of nodes by referring to the triplet of the first node plus the last node number and the step (increment) in node numbering.
- All nodes on a straight LINE (infinite or a segment) by referring to two points.
- All nodes in an infinite PLANE by referring to either:
  — three points in the plane (3-PLANE option), or
  — one point in the plane and one point on a vector perpendicular to the plane (2-PLANE option).
- All nodes inside a VOLUME by referring to two points being the diagonally opposite corners of a box with side surfaces parallel with the coordinate system planes XY, YZ and ZX (or parallel interpreted in the space of the named coordinate system if the USE-COORDINATE option has been chosen).
- All nodes belonging to a previously defined set.
- Several nodes by repeatedly using any of the above selection methods (stop selection by END).
- ALL nodes.

Whether a certain node lies on the given straight line, or lies in the given plane, or is located within the given volume is decided by a coordinate tolerance; see the SET COORDINATE-TOLERANCE command.

5.1.2 Graphical Selection

In addition to the above line-mode commands you may select nodes graphically by clicking or dragging a rubberband. Such graphical selection is logged as the line-mode command by which you enclose the triplets of several nodes in parentheses. When dragging a rubberband you do not even need to type in the enclosing parentheses as these are filled in by the dragging operation.

Also, whenever a single node is to be selected, either after the line-mode option SINGLE or inside any of the other options the node may be clicked as an alternative to typing in the node number triplet.

5.1.3 Command Syntax for Node Selection

Whenever selecting nodes is required the command syntax is:

<table>
<tr><td colspan="7">[GLOBAL-COORDINATES]</td><td rowspan="11">*</td></tr>
<tr><td colspan="2">[USE-COORDINATE-SYSTEM</td><td colspan="5">coord-name]</td></tr>
<tr><td>(</td><td>{ supno index nodeno }*</td><td colspan="5">)</td></tr>
<tr><td colspan="2">SINGLE</td><td>supno</td><td>index</td><td colspan="3">nodeno*</td></tr>
<tr><td colspan="2">GROUP</td><td>supno</td><td>index</td><td>node1</td><td>node2</td><td>nstep</td></tr>
<tr><td colspan="2" rowspan="2">LINE</td><td>SEGMENT</td><td rowspan="2">point</td><td colspan="3" rowspan="2">*2</td></tr>
<tr><td>INFINITE</td></tr>
<tr><td colspan="2" rowspan="2">PLANE</td><td>3-PLANE</td><td>point</td><td colspan="3">*3</td></tr>
<tr><td>2-PLANE</td><td>point</td><td colspan="3">*2</td></tr>
<tr><td colspan="3">VOLUME</td><td>point</td><td colspan="3">*2</td></tr>
<tr><td colspan="2">SET</td><td colspan="5">setname</td></tr>
<tr><td colspan="8">ALL</td></tr>
<tr><td colspan="8">END</td></tr>
</table>

Where 'point' in the command syntax above represents specifying a point as follows:

NODE	supno	index	nodeno
COORDINATE	x	y	z
LOCAL-COORDINATE	r	phi	z

The LINE, PLANE and VOLUME alternatives offer selection by referring to points in space. These lines, planes and volumes may be interpreted in the cartesian coordinate space of the superelement — the GLOBAL-COORDINATES option — or in a cylindrical coordinate space — the USE-COORDINATE-SYSTEM option. Figure 5.1 illustrates this. Such a cylindrical coordinate system must previously have been defined by the COORDINATE-SYSTEM command. You may switch back and forth between these two spaces within the same selection sequence, i.e. before giving END. The space chosen last is valid for the subsequent LINE, PLANE and VOLUME commands. If neither the GLOBAL-COORDINATES nor the USE-COORDINATE-SYSTEM space is given the former is valid.

The points defining the lines, planes and volumes may, as shown by the table explaining 'point' above, either be nodes (selected by giving node number triplets) or specified by coordinates.

When a cylindrical coordinate space has been referred to (by USE-COORDINATE-SYSTEM) in a selection sequence the point coordinates may optionally be given in this cylindrical coordinate system (the LOCAL-COORDINATE option). Note that the choice between COORDINATE and LOCAL-COORDINATE is merely for giving the point coordinates. The line, plane or volume is still interpreted in the global cartesian or given cylindrical space according to the choice between GLOBAL-COORDINATES and USE-COORDI-

NATE-SYSTEM. Normally though, you want to use the LOCAL-COORDINATE option when the line, plane or volume is interpreted in a cylindrical coordinate space and the COORDINATE option when they are interpreted in the cartesian space.

Note: You may also use the TAG command to pre-select nodes and refer to these TAGGED nodes rather than selecting nodes directly within the command in question.

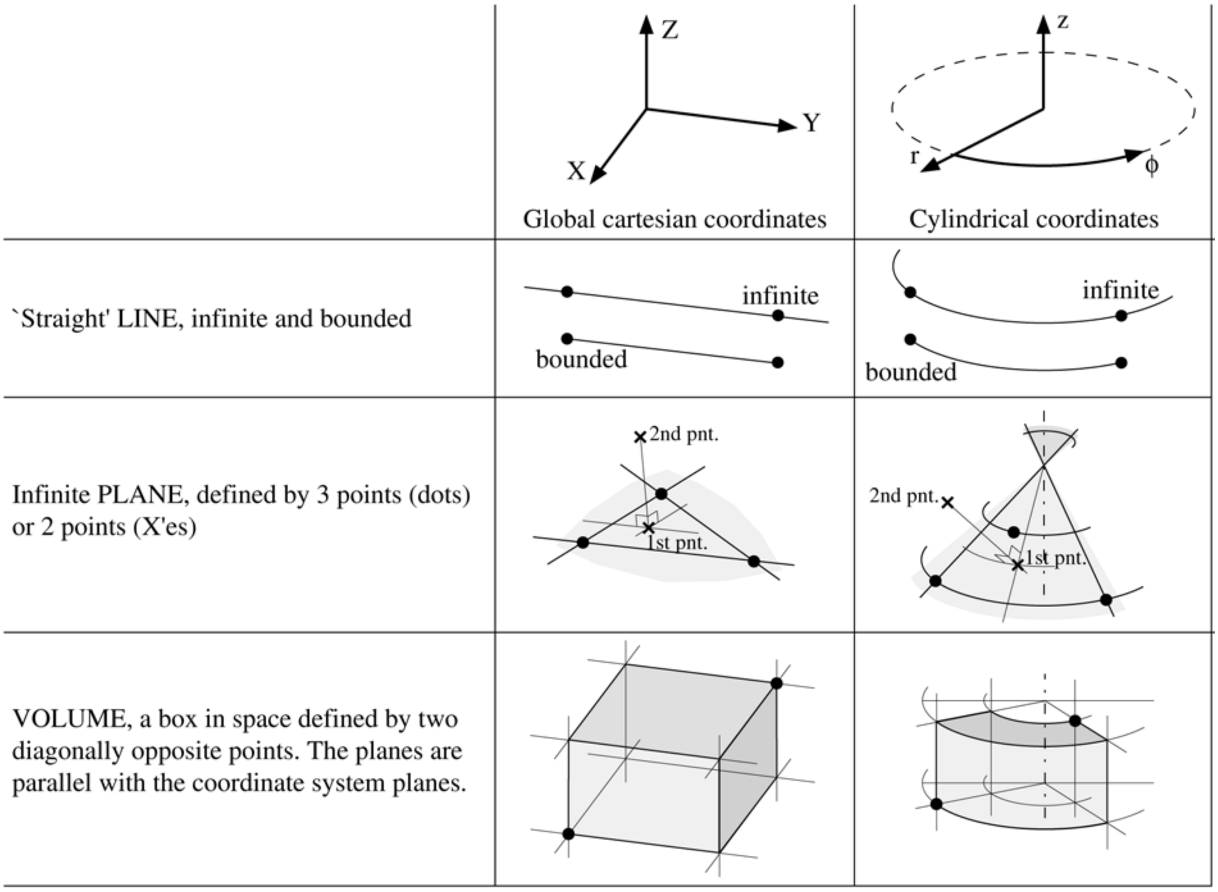


Figure 5.1 Node select alternatives

PARAMETERS:

GLOBAL-COORDINATES	The lines, planes and volumes subsequently given are to be interpreted in the cartesian coordinate space of the superelement in question.
USE-COORDINATE-SYSTEM	The lines, planes and volumes subsequently given are to be interpreted in the subsequently named cylindrical coordinate space.
coord-name	Name of a previously defined cylindrical coordinate system.

( )	Parentheses enclose one or several node number triplets.
supno	First level superelement number to which the node belongs.
index	First level superelement index to which the node belongs.
nodeno	Node number.
SINGLE	A single node is to be selected.
GROUP	A group of nodes are to be selected.
node1	The first node number.
node2	The last node number.
nstep	The step (increment) in node numbering between node1 and node2.
LINE	All nodes on a straight line (or ‘straight’ in a specified cylindrical coordinate system) defined by two points are selected. The tolerance or ‘thickness’ of the line is defined by the SET COORDINATE-TOLERANCE command.
SEGMENT	Only the nodes on the line between the two points are selected.
INFINITE	All nodes on the infinite line are selected.
NODE	The point is the subsequently given node.
COORDINATE	The point is defined by the subsequently given cartesian coordinates.
x y z	Coordinates referring to the cartesian system of the superelement.
LOCAL-COORDINATE	The point is defined by the subsequently given coordinates referring to the cylindrical coordinate system coord-name. This option will only appear if the command USE-COORDINATE-SYSTEM has previously been given within the current selection sequence.
r phi z	Coordinates referring to the cylindrical coordinate system coord-name.
PLANE	All nodes in an infinite plane defined by two or three points are selected. The tolerance or ‘thickness’ of the plane is defined by the SET COORDINATE-TOLERANCE command.
3-PLANE	The plane is defined by three points; see Figure 5.1.
2-PLANE	The plane is defined by two points; see Figure 5.1.

VOLUME	All nodes inside a box-shaped volume are selected; see Figure 5.1.
SET	Select all nodes of a given set.
setname	Name of a previously defined set.
ALL	Select all nodes of the current superelement.
END	Stop selecting more nodes.

Note: Use the command END to conclude a node selection sequence. Do not use the '..' command as that will involve termination of the current command with no nodes selected.

5.2 Detailed Description of Commands

The input commands are described in the following. The commands and sub-commands are described in alphabetic order. Below is a list of all main (basic level) commands.

ASSEMBLY

<table>
<tr><td rowspan="2">ASSEMBLY</td><td>NEW</td><td rowspan="2">supno</td></tr>
<tr><td>OLD</td></tr>
</table>

PURPOSE:

This command creates a new superelement and makes it the current one — the NEW option — or an existing superelement is made the current one — the OLD option.

A NEW superelement will be empty until one or more superelements are included into it. It will then become a second or higher level superelement.

On OLD superelement is either:

- A first level superelement, typically created by Preframe or Prefem, and already read into Presel.
- A higher level superelement previously created by Presel.

The current superelement is the one:

- Displayed when issuing the DISPLAY CURRENT-SUPERELEMENT command.
- For which boundary conditions are given when issuing the BOUNDARY command.
- Into which superelements are included when issuing the INCLUDE command.
- For which load combinations are given when issuing the LOAD command.
- Etc.

PARAMETERS:

supno	The superelement number. A vacant superelement number for the NEW option, an existing one for the OLD option.

BOUNDARY

<table>
<tr><td rowspan="5">BOUNDARY</td><td>FREE</td><td rowspan="5">*6</td><td rowspan="5">[</td><td colspan="2">GLOBAL</td><td rowspan="5">]</td><td rowspan="5">...</td></tr>
<tr><td>FIXED</td><td>LOCAL-COORDINATE-SYSTEM</td><td>coord-name</td></tr>
<tr><td>PRESCRIBED</td><td rowspan="3">TRANSFORMATION</td><td rowspan="3">trano</td></tr>
<tr><td>SUPER</td></tr>
<tr><td>fixcode</td></tr>
</table>

<table>
<tr><td rowspan="4">...</td><td>SELECT</td><td>select-nodes</td></tr>
<tr><td colspan="2">TAGGED</td></tr>
<tr><td colspan="2">UNTAGGED</td></tr>
<tr><td colspan="2">END</td></tr>
</table>

PURPOSE:

The command defines boundary conditions for the current superelement which must be a higher level superelement, i.e. boundary conditions cannot be defined within Presel for first level superelements. The following boundary conditions may be defined for each individual degree of freedom (d.o.f.) of the nodes:

FREE	=	Free to move
FIXED	=	Fixed at zero displacement
PRESCRIBED	=	Prescribed displacement or acceleration (value is given by the LOAD command)
SUPER	=	Super d.o.f.

In addition, the boundary conditions LINEAR and SUPERL are defined using the LINEAR-DEPENDENCY command. SUPERL has exactly the same effect as SUPER, only that it was defined within the LINEAR-DEPENDENCY command.

Note that only supernodes (or super d.o.f.s) will appear as nodes (or d.o.f.s) in the higher level superelements into which this superelement is included. All other boundary conditions involve that the node (or d.o.f.) will not exist at higher level superelements. See Section 3.2.6 for more information on this.

Nodes for which no boundary conditions are given will by default have all its d.o.f.s as FREE.

A node may have less that six d.o.f.s. This will for example be the case for membrane models in which the nodes have three d.o.f.s. Another example is when not all six d.o.f.s were defined as super for the included lower level superelement(s). When boundary conditions are given for such nodes the boundary conditions for non-existent d.o.f.s will be ignored. If for example only the translations in X and Y and the rotation about Z exist the node is fixed by the sequence:

FIX FIX * * * FIX

where * means that any legal boundary condition may be given, it will be ignored anyway.

A node for which boundary conditions previously has been given will not be affected by a new boundary command (that includes the node in question). I.e. boundary conditions are neither overwritten nor ‘accummulated’. The only way to given a node new boundary conditions is to delete the current conditions (using the DELETE command) and then redefine them.

The boundary conditions may be given both in a rotated cartesian coordinate system (the TRANSFORMATION option) and a cylindrical coordinate system (the LOCAL-COORDINATE-SYSTEM option). Both these systems must previously have been defined by the TRANSFORMATION and COORDINATE-SYSTEM commands respectively.

The boundary conditions may be verified by the LABEL BOUNDARY-CONDITION-SYMBOL and the PRINT NODE BOUNDARY-CONDITIONS commands. Boundary conditions are deleted by the DELETE BOUNDARY command.

PARAMETERS:

fixcode	0 = FREE, 1 = FIXED, 3 = PRESCRIBED and 4 = SUPER.
GLOBAL	The boundary conditions are specified in the global coordinate system.
LOCAL-COORDINATE-SYSTEM	The boundary conditions are specified in a cylindrical coordinate system.
coord-name	The name of the cylindrical coordinate system previously defined by the COORDINATE-SYSTEM command.
TRANSFORMATION	The boundary conditions are specified in a rotated coordinate system.
trano	Transformation reference number previously defined by the TRANSFORMATION command.
SELECT	Nodes are to be selected now.
select-nodes	Select nodes; see Section 5.1.
TAGGED	Refers to previously selected (tagged) nodes; see the TAG/UNTAG commands.
UNTAGGED	Refers to all but the previously selected (tagged) nodes; see the TAG/UNTAG commands.

NOTES:

The brackets denote optional parameters. I.e. if you do not specify any coordinate system then the global system is used by default.

CHANGE

CHANGE	LINEAR-DEPENDENCY	...
	LOAD	
	SET	
	TRANSFORMATION	

PURPOSE:

The command changes data previously defined.

The CHANGE LINEAR-DEPENDENCY and CHANGE LOAD commands are described in more detail in the following.

The CHANGE SET and CHANGE TRANSFORMATION commands, however, have identical syntax with the commands defining the data. Refer to the DEFINE SET and TRANSFORMATION commands for details.

CHANGE LINEAR-DEPENDENCY

...	LINEAR-DEPENDENCY	...

...	{	dep-node-triplet	dep-dof	{	indep-node-triplet	indep-dof	beta	}*	}*

PURPOSE:

The command changes linear dependencies between nodes. Only the linear dependency factor beta may be changed. The linear dependency may originally have been defined by either the GENERAL-NODE-DEPENDENCY or the TWO-NODE-DEPENDENCY option; see the LINEAR-DEPENDENCY command.

PARAMETERS:

dep-node-triplet	Node number triplet (supno index nodeno) previously defined as dependent.
dep-dof	D.o.f. previously defined as dependent of the indep-dof of the indep-node-triplet, choose either: X, Y or Z: Translations in X-, Y- or Z-directions R-X, R-Y or R-Z: Rotations about the X-, Y- or Z-directions
indep-node-triplet	Node number triplet (supno index nodeno) previously defined as independent, the one being supernode.
indep-dof	D.o.f. previously defined as independent, choose either: X, Y or Z: Translations in X-, Y- or Z-directions R-X, R-Y or R-Z: Rotations about the X-, Y- or Z-directions
beta	New linear dependency factor.

CHANGE LOAD

<table>
<tr><td rowspan="2">...</td><td rowspan="2">LOAD</td><td>NODE</td><td>lc</td><td rowspan="2">...</td></tr>
<tr><td colspan="2">END</td></tr>
</table>

PURPOSE:

The command changes nodal loads previously defined by the LOAD NODE command.

Changing a nodal load is done in the same way as it was defined with one exception: a load *index* has to be given. The load index is used to distinguish between different nodal loads for the same node for the same load case. For example, a nodal force defined for the second time for the same node for the same load case is given index 2.

The PRINT LOAD command gives an overview of the loads including the automatically assigned load indexes, refer to this table when a nodal load is to be changed.

Rather than describing the CHANGE LOAD NODE command in detail reference is made to the LOAD NODE command.

Load combinations cannot be changed, rather they must be deleted (DELETE LOAD COMBINATION) and redefined.

COORDINATE-SYSTEM

COORDINATE-SYSTEM	coord-name	CYLINDRICAL	...

<table>
<tr><td rowspan="2">...</td><td>COORDINATE</td><td>x</td><td>y</td><td>z</td><td rowspan="2">*3</td></tr>
<tr><td>NODE</td><td>supno</td><td>index</td><td>nodeno</td></tr>
</table>

PURPOSE:

The command defines a cylindrical coordinate system. This coordinate system may conveniently be used for selecting nodes (see Section 5.1) and for defining boundary conditions.

A cylindrical coordinate system is defined by three points: its origin, a point defining its z-axis and a point defining its ϕ=0 plane (which determines the r-axis). See Figure 5.2. The three points may be defined by giving coordinates in the cartesian system of the superelement or nodes may be referred to.

PARAMETERS:

coord-name	User-given name of the coordinate system.
CYLINDRICAL	A cylindrical coordinate system is defined.
COORDINATE	Define point by giving its coordinates.
x y z	Coordinates in the superelement’s cartesian system.
NODE	Refer to nodes.
supno index nodeno	The node number triplet.

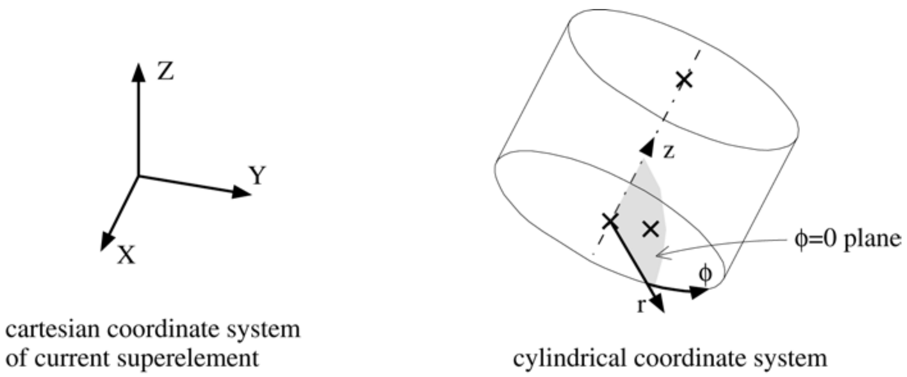


Figure 5.2 Cylindrical and spherical coordinate systems

NOTES:

Note that the coordinate system is only defined for, and therefore available to, the current superelement.

Coordinate systems defined are printed by the PRINT TRANSFORMATION command. The coordinate system name (coord-name) is not given in the printout but rather an internally assigned number.

DEFINE SET

<table>
<tr><td rowspan="4">DEFINE</td><td rowspan="4">SET</td><td rowspan="4">setname</td><td>intersection-with</td><td rowspan="3">NODE</td><td rowspan="3">select-nodes</td></tr>
<tr><td>SUBTRACT-BY</td></tr>
<tr><td>UNION-WITH</td></tr>
<tr><td colspan="3">END</td></tr>
</table>

PURPOSE:

The command defines a set of nodes that may be referred to in commands where selecting nodes is required. DEFINE SET creates a new set while CHANGE SET changes an existing set. The command syntaxes of these two commands are identical and based on standard set operators.

Initially, after giving the command DEFINE SET and entering a name the set is empty. The first operation to do will therefore be to add to the set by the UNION-WITH command. Thereafter, repetitive set operations may be performed until the content of the set is as desired. The operations are executed consecutively, the order of the operations are therefore of consequence. Conclude the definition (or changing) of the set by entering END.

PARAMETERS:

setname	User-given name of the set to define (maximum 8 characters and starting with a letter).
INTERSECTION-WITH	All nodes except those subsequently selected will be removed from the set. I.e. the new contents will be the intersection between the current contents and the subsequent selection.
SUBTRACT-BY	The subsequently selected nodes will be removed from the set.
UNION-WITH	The subsequently selected nodes will be added to the set.
NODE	Nodes are to be selected (the only choice).
select-nodes	Select nodes; see Section 5.1.

DELETE

<table>
<tr><td rowspan="17">DELETE</td><td>ASSEMBLY</td><td colspan="2">supno</td></tr>
<tr><td rowspan="4">BOUNDARY</td><td>SELECT</td><td>select-nodes</td></tr>
<tr><td colspan="2">TAGGED</td></tr>
<tr><td colspan="2">UNTAGGED</td></tr>
<tr><td colspan="2">END</td></tr>
<tr><td rowspan="2">INCLUDED</td><td>supno</td><td>index</td></tr>
<tr><td colspan="2">END</td></tr>
<tr><td rowspan="4">LINEAR-DEPENDENCY</td><td>SELECT</td><td>select-nodes</td></tr>
<tr><td colspan="2">TAGGED</td></tr>
<tr><td colspan="2">UNTAGGED</td></tr>
<tr><td colspan="2">END</td></tr>
<tr><td rowspan="3">LOAD</td><td>COMBINATION</td><td>glc</td></tr>
<tr><td>NODE</td><td>...</td></tr>
<tr><td colspan="2">END</td></tr>
<tr><td>TRANSFORMATION</td><td colspan="2">trano</td></tr>
</table>

PURPOSE:

The command deletes data previously defined. Only the DELETE LOAD NODE command is described in detail in the following. Notes are given below for the other alternatives. Otherwise see the commands defining the data.

PARAMETERS:

ASSEMBLY	Delete an assembly, normally a higher level superelement. A first level superelement may, however, also be deleted with the effect that it will be as if the superelement had not been read into Presel. All data relating to the superelement are deleted. The superelement to delete cannot be part of a higher level superelement, i.e. it cannot have been included in any assembly.
supno	Superelement number to be deleted.
BOUNDARY	Delete boundary conditions for the current superelement which must be a higher level superelement, i.e. boundary conditions cannot be deleted for first level superelements. The selected nodes will then be FREE for all d.o.f.s. Note that the boundary conditions LINEAR and SUPERL (see the LINEAR-DE-

	PENDENCY command) can only be deleted using the DELETE LINEAR-DEPENDENCY command.
SELECT	Nodes are to be selected now.
select-nodes	Select nodes; see Section 5.1.
TAGGED	Refers to previously selected (tagged) nodes; see the TAG/UNTAG commands.
UNTAGGED	Refers to all but the previously selected (tagged) nodes; see the TAG/UNTAG commands.
INCLUDED	Delete a lower level superelement that previously has been included in the current higher level superelement. The current superelement cannot itself be part of an assembly.
supno index	The superelement number and index to be deleted.
LINEAR-DEPENDENCY	Delete linear dependencies between nodes. The linear dependencies of all selected dependent nodes are deleted. Note that the *dependent* nodes and not the independent nodes are to be selected. Also note that this command will delete the LINEAR boundary condition of the dependent node. It will also delete the SUPERL (or SUPER) boundary condition of the independent nodes unless other nodes still are linearly dependent on them.
LOAD	Delete a load.
COMBINATION	Delete a load combination for a higher level superelement.
NODE	Delete a nodal load for a higher level superelement. See a specific description for this alternative below.
TRANSFORMATION	Delete a previously defined transformation.
trano	The transformation number to be deleted.

DELETE LOAD NODE

...	LOAD	NODE	lc	...

<table>
<tr><td rowspan="10">...</td><td rowspan="5">ALL</td><td colspan="2" rowspan="4">YES</td><td>SELECT</td><td colspan="2">select-nodes</td></tr>
<tr><td colspan="3">TAGGED</td></tr>
<tr><td colspan="3">UNTAGGED</td></tr>
<tr><td colspan="3">END</td></tr>
<tr><td colspan="5">NO</td></tr>
<tr><td colspan="2">FORCE</td><td rowspan="4">...</td><td>SELECT</td><td>select-nodes</td><td rowspan="4">index</td></tr>
<tr><td colspan="2">PRESCRIBED-DISPLACEMENT</td><td colspan="2">TAGGED</td></tr>
<tr><td colspan="2" rowspan="2">PRESCRIBED-ACCELERATION</td><td colspan="2">UNTAGGED</td></tr>
<tr><td colspan="2">END</td></tr>
<tr><td colspan="6">END</td></tr>
</table>

PURPOSE:

The command deletes loads. See the LOAD command for a more detailed explanation of the load types.

This command differs from the command defining the load in that a load index must be given. The load index is used to distinguish between individual loads of the same type for the same node for the same load case. For example, a nodal force defined for the second time for the same node for the same load case is given index 2. Note that load indexes may change after deleting a load as the index always goes from 1 to N where N is the number of loads of the same type for that particular node.

PARAMETERS:

lc	Load case number.
ALL	Delete all loads.
YES/NO	Confirm deletion.
SELECT	Nodes are to be selected now.
select-nodes	Select nodes; see Section 5.1.
TAGGED	Refers to previously selected (tagged) nodes; see the TAG/UNTAG commands.
UNTAGGED	Refers to all but the previously selected (tagged) nodes; see the TAG/UNTAG commands.
FORCE	Delete nodal force loads.

PRESCRIBED-ACCELERATION	Delete nodal acceleration loads.
PRESCRIBED-DISPLACEMENT	Delete nodal displacement loads.
index	Load index, either select one index or all by entering the text ALL.

DISPLAY

<table>
<tr><td rowspan="7">DISPLAY</td><td colspan="3">CURRENT-SUPERELEMENT</td></tr>
<tr><td rowspan="4">LOAD</td><td>LOADED-SUPERELEMENT</td><td>glc</td></tr>
<tr><td>FIRST-CONTRIBUTING-LOAD</td><td>glc</td></tr>
<tr><td colspan="2">NEXT-CONTRIBUTING-LOAD</td></tr>
<tr><td colspan="2">END</td></tr>
<tr><td>LOCATE-SUPERELEMENT</td><td colspan="2">supno</td></tr>
<tr><td>SPECIFIED-SUPERELEMENT</td><td colspan="2">supno</td></tr>
</table>

PURPOSE:

The command displays superelements, optionally with information about loads. The nodes of the superelement are shown by small coloured dots (yellow for free nodes and blue for supernodes). These node symbols may be switched off (and on again) by SET GRAPHICS NODE-SELECTION.

Node symbols, node numbers and boundary conditions may be added by the LABEL command.

Note that there is also a DISPLAY command within the command sequence for including a superelement in an assembly. The purposes of these two DISPLAY commands are different and should not be confused. See the INCLUDE supno DISPLAY command.

PARAMETERS:

CURRENT-SUPERELEMENT	Display the current superelement. The current superelement is set by the ASSEMBLY command.
LOAD	Display the current superelement with information verifying the load combination. The current superelement must be a higher level superelement. Note that loads defined for first level superelements cannot be displayed or verified in Presel.
LOADED-SUPERELEMENT	Colour code first level superelement occurrences according to how many local load cases each contributes with to the given global loadcase.
glc	Global loadcase, i.e. a load combination of the current higher level superelement.
FIRST-CONTRIBUTING-LOAD	This option is used in combination with the option NEXT-CONTRIBUTING-LOAD. Combined the two options colour code first level superelement occurrences according to which loadcases they contribute with to a given global loadcase. FIRST-CONTRIBUTING-LOAD displays with a separate colour the first level superelements that contribute with their load-

	case 1. If no superelements contribute with their loadcase 1 then the lowest contributing loadcase — when accounting for all first level superelements — is shown instead. Thereafter, repetitive use of NEXT-CONTRIBUTING-LOAD steps through all contributing loadcases from first level superelements. For each loadcase the contributing superelements are displayed with a separate colour. The load factors are for each display printed on top of the colour coded superelements.
NEXT-CONTRIBUTING-LOAD	See explanation of FIRST-CONTRIBUTING-LOAD above.
LOCATE-SUPERELEMENT	Display the specified first level superelement with a separate colour in a display of the current higher level superelement. See also the command SET GRAPHICS PRESENTATION COLOUR-SUPERELEMENTS.
supno	Superelement number.
SPECIFIED-SUPERELEMENT	Display the specified superelement alone. Note that the current superelement is not changed by this option, i.e. DISPLAY CURRENT-SUPERELEMENT will revert to displaying the current superelement. This option differs from LOCATE-SUPERELEMENT in that only the specified superelement is displayed and it need not be a first level superelement.

EXIT

EXIT

PURPOSE:

The command interrupts the program execution. All files opened are properly saved and closed. The user may resume the superelement assembling at a later stage by referring to the model file and command log file as ‘old’ when re-entering Presel.

HELP

HELP	GENERAL-SYNTAX
	SPECIAL-KEYS
	STATUS-LIST
	SUPPORT

PURPOSE:

The command provides information on various subjects. Except for the STATUS-LIST option the information is printed in the message window.

PARAMETERS:

GENERAL-SYNTAX	Information on how to enter commands and text is provided.
SPECIAL-KEYS	Information on some special keys is provided.
STATUS-LIST	This command is obsolete. See Section 1.4 for looking up information in the Status List.
SUPPORT	The telephone and facsimile numbers and the Internet address for requesting support is printed together with detailed information on the program version used. This information is of importance in connection with support requests.

INCLUDE

<table>
<tr><td rowspan="15">INCLUDE</td><td rowspan="15">supno</td><td>CHECK-INCLUDE</td><td rowspan="15">...</td></tr>
<tr><td>DECODE-T-MATRIX</td></tr>
<tr><td>DISPLAY</td></tr>
<tr><td>DISTANCE-CHECK</td></tr>
<tr><td>END-DO-NOT-INCLUDE</td></tr>
<tr><td>LOCATION</td></tr>
<tr><td>MIRROR</td></tr>
<tr><td>NOPRINT-CHECK-INCLUDE</td></tr>
<tr><td>PERFORM-INCLUDE</td></tr>
<tr><td>POSITION</td></tr>
<tr><td>PRINT-INV-T-MATRIX</td></tr>
<tr><td>PRINT-T-MATRIX</td></tr>
<tr><td>RESET-T-MATRIX</td></tr>
<tr><td>ROTATE</td></tr>
<tr><td>TRANSLATE</td></tr>
</table>

PURPOSE:

The command starts the process of including a superelement in the current superelement assembly. See Section 3.2.2 for a tutorial in how to use the INCLUDE command.

Initially, the superelement being included will be position with its coordinate system overlapping the coordinate system of the superelement assembly. It may then be moved by repetitive use of the sub-commands TRANSLATE, ROTATE, MIRROR and POSITION until it is properly positioned. The sub-command DISPLAY will at any time show the current position of the superelement being included.

NOPRINT-CHECK-INCLUDE checks and tabulates the match of the nodes of the superelement being included and the current superelement. (CHECK-INCLUDE does the same but produces more output.) It is mandatory to perform this check.

PERFORM-INCLUDE performs and concludes the inclusion of the superelement in the current superelement assembly.

The various INCLUDE sub-commands listed above are explained in the following.

PARAMETERS:

supno	Superelement number being included in the current higher level superelement.

INCLUDE supno CHECK-INCLUDE

...	CHECK-INCLUDE

PURPOSE:

The sub-command compares and tabulates the match between supernodes of the superelement being included and the nodes of the current superelement assembly. The typical appearance of the table is shown in Figure 5.3.

```
SUPER ELEMENT TYPE:       21  LEVEL:       2  COTOL:        0.100

INCLUDE NODES        BOU  ASSEMBLY NODES
SUP.EL SUP.EL EXT.   NOT  SUP.EL SUP.EL EXT.        GLOBAL COORDINATES
TYPE   INDEX  NO.    OK   TYPE   INDEX  NO.       X          Y          Z
------ ------ ------ ---  ------ ------ ------ ---------- ---------- ---------
    11      1    101          11      2    103    20.000     20.000      0.000   <- A
    11      1    103                               0.000     20.000      0.000
    11      1    301          11      2    303    18.000     18.000     20.000
    11      1    303                               2.000     18.000     20.000   <- B
    11      1    501          11      2    503    16.000     16.000     40.000
    11      1    503                               4.000     16.000     40.000
          NO. OF INTERNAL NODES:                 1
          NO. OF SUPER NODES MATCHING:           3
          NO. OF SUPER NODES NOT MATCHING:       3
          NO. OF NODES:                          7
```

Nodes of the superelement being included

Asterisk here signals discrepancy of boundary conditions

Nodes of the superelement assembly

Summary information

Coordinates in the cartesian system of the superelement assembly

Figure 5.3 CHECK-INCLUDE tabulates match between nodes, here for first level superelements

The table header contains information about including a superelement in the second level superelement assembly 21. The coordinate tolerance is 0.1 (see the SET COORDINATE-TOLERANCE command). The table contains the following information:

- The first line, marked A, says that the node 11 1 101 (a triplet) of the superelement being included matches node 11 2 103 (a triplet) of the superelement assembly. And the coordinates of these nodes are (20,20,0).
- The fourth line, marked B, says that node 11 1 303 of the superelement being included does not match any node of the assembly. Its coordinates are (2,18,20).
- The summary at the bottom says that:

  — the assembly has 1 node not matched by any node of the superelement being included,

  — 3 pairs of nodes match,

  — 3 nodes of the superelement being included does not match any of the assembly nodes and

  — the total number of nodes in the assembly, counting the ones of the superelement being included, is 7.

Higher level superelements will have nodes with more than one triplet (see Section 3.2.6). When higher level superelements are assembled into even higher level superelements all these triplets will appear in the table of matching nodes. The typical appearance of the table will then be as shown in Figure 5.4

```
SUPER ELEMENT TYPE:       31  LEVEL:       3  COTOL:         0.100

INCLUDE NODES        BOU  ASSEMBLY NODES
SUP.EL SUP.EL EXT.   NOT  SUP.EL SUP.EL EXT.        GLOBAL COORDINATES
TYPE   INDEX  NO.    OK   TYPE   INDEX  NO.        X            Y            Z
------ ------ ------ ---  ------ ------ ------ ---------- ---------- ----------
  11      2    103          12      1    703     20.000     20.000      0.000   <-A
  11      3    101
  11      2    303          12      1    803     18.000     18.000     20.000   <-B
  11      3    303    *     12      2    801
          NO. OF INTERNAL NODES:                   12
          NO. OF SUPER NODES MATCHING:              2
          NO. OF SUPER NODES NOT MATCHING:          0
          NO. OF NODES:                            14
```

Nodes of the superelement being included

Asterisk here signals discrepancy of boundary conditions

Nodes of the superelement assembly

Summary information

Coordinates in the cartesian system of the superelement assembly

Figure 5.4 CHECK-INCLUDE tabulates match between nodes, here for higher level superelements

The table header now informs that a superelement is being included in the third level superelement assembly 31. The table contains the following information:

- The two first lines, marked A, says that the node 11 2 103 (a triplet) which is the same node as 11 3 101 and both belonging to the superelement being included matches node 12 1 703 of the superelement assembly. The coordinates of these nodes are (20,20,0).
- The third and fourth lines, marked B, says that node 11 2 303 which is the same node as 11 3 303 and both belonging to the superelement being included matches node 12 1 803 which is the same node as 12 2 801 both belonging to the assembly. The coordinates are (18,18,20).
- The asterisk signals that there is a discrepancy in boundary condition of the matching pair of nodes marked B. This means that the superelement cannot be included in the assembly. See Section 3.2.6 about requirements to nodes.
- The summary at the bottom says that:

  — the assembly has 12 nodes not matched by any nodes of the superelement being included,

  — 2 pairs of nodes match,

  — 0 nodes of the superelement being included does not match any of the assembly nodes (all match) and

  — the total number of nodes in the assembly, counting the ones of the superelement being included, is 14.

NOTES:

CHECK-INCLUDE or NOPRINT-CHECK-INCLUDE is mandatory and must be given before PERFORM-INCLUDE.

The DISTANCE-CHECK sub-command can be used to find the distance between the two nodes. If this distance is greater than the coordinate tolerance printed in the heading of the tables the nodes will not match. Assuming that the superelement being included has been positioned correctly there are only two ways to get non-matching nodes to match: you must either correct the first level superelements (leave Presel and re-run after the correction) or increase the coordinate tolerance (see the SET COORDINATE-TOLERANCE command).

INCLUDE supno DEDECODE-T-MATRIX

...	DECODE-T-MATRIX

PURPOSE:

The sub-command prints the transformation matrix containing the accumulated translations, rotations and mirrorings of the superelement being included. Also see the PRINT-T-MATRIX sub-command. The table looks like this:

```
MIRROR ABOUT XY-PLANE:             NO
ROTATION ABOUT GLOBAL X-AXIS:      0.0000
ROTATION ABOUT GLOBAL Y-AXIS:      0.0000
ROTATION ABOUT GLOBAL Z-AXIS:     90.0000
TRANSLATION IN X-DIRECTION:       20.0000
TRANSLATION IN Y-DIRECTION:        0.0000
TRANSLATION IN Z-DIRECTION:        0.0000
```

NOTES:

The translations and rotations refer to the coordinate system of the superelement assembly.

Starting from the initial position of the superelement being included (for example after RESET-T-MATRIX) the translations and rotations must be made in the given sequence (first mirror about the XY-plane if relevant, then rotate about X, etc.) in order to yield the position resulting from the accumulated transformations.

INCLUDE supno DISPLAY

...	DISPLAY

PURPOSE:

The sub-command displays the current position of the superelement being included on top of the superelement assembly.

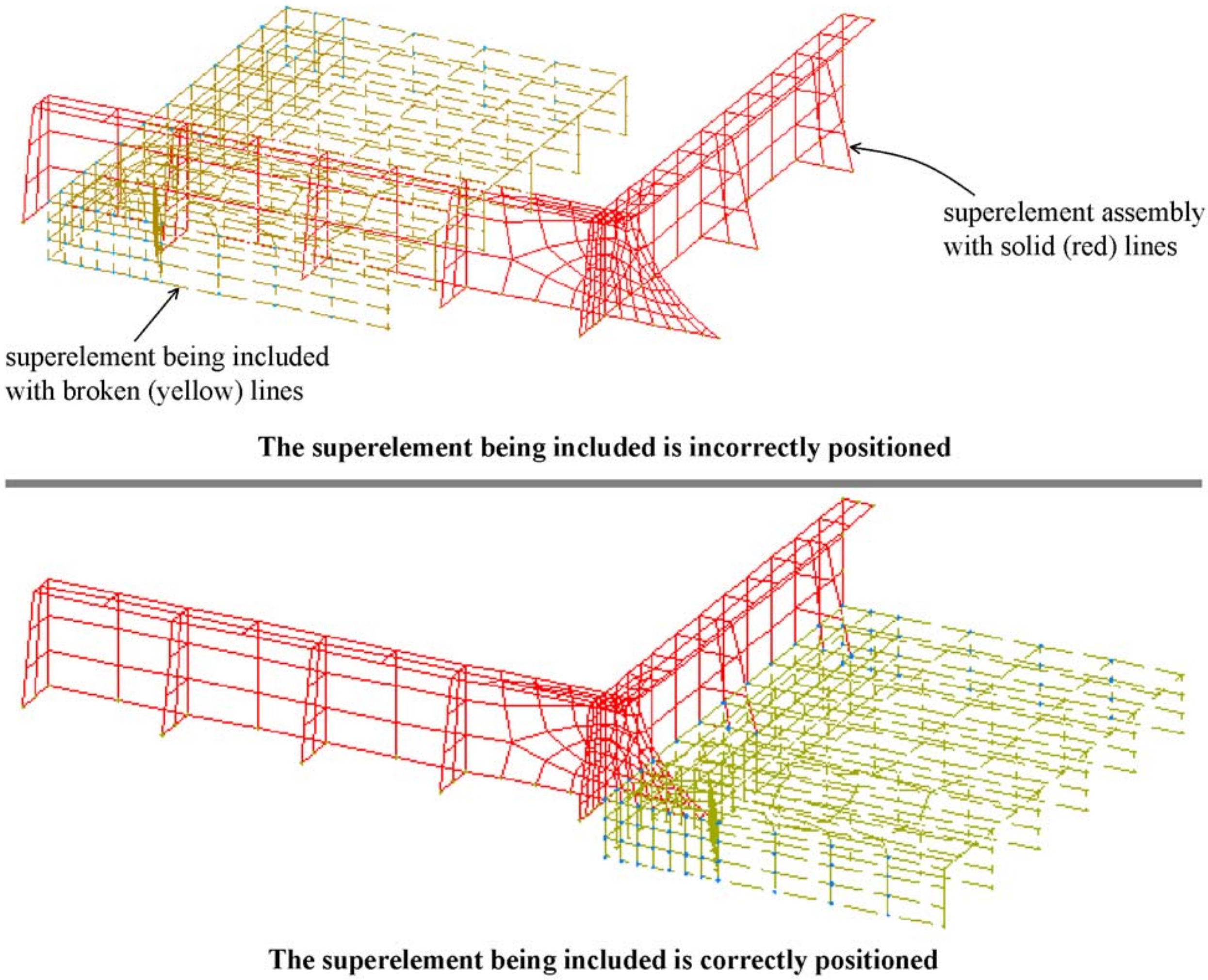


Figure 5.5 DISPLAY sub-command within the INCLUDE command

INCLUDE supno DISTANCE-CHECK

<table>
<tr><td rowspan="2">...</td><td rowspan="2">DISTANCE-CHEKC</td><td>NODE</td><td>supno</td><td>index</td><td>nodeno</td><td rowspan="2">*2</td></tr>
<tr><td>COORDINATE</td><td>x</td><td>y</td><td>z</td></tr>
</table>

PURPOSE:

The sub-command computes and prints the distance between a node or point in the superelement assembly and the corresponding node or point in the superelement being included. The node/point of the superelement assembly is given first.

If the COORDINATE alternative is chosen the point does not have to correspond to a node. The coordinates are given in the coordinate systems of the assembly and superelement being included, respectively.

PARAMETERS:

NODE	Refer to a node triplet.
supno index nodeno	The node number triplet.
COORDINATE	Refer to a point by using coordinates.
x y z	The point coordinates.

INCLUDE supno END-DO-NOT-INCLUDE

...	END-DO-NOT-INCLUDE

PURPOSE:

The sub-command aborts the inclusion process of the superelement and prepares for including another superelement.

To merely discard the given transformations of the superelement currently being included use the RESET-T-MATRIX command.

INCLUDE supno LOCATION

<table>
<tr><td rowspan="4">...</td><td rowspan="4">LOCATION</td><td>CHANGE</td><td>oldloc</td><td>newloc</td></tr>
<tr><td>CREATE</td><td colspan="2">loc</td></tr>
<tr><td>USE</td><td>refloc</td><td>modloc</td></tr>
<tr><td>DELETE</td><td colspan="2">oldloc</td></tr>
</table>

PURPOSE:

The sub-command is used in connection with the LOAD ASSEMBLY command. It creates and modifies location strings for superelements being included. See Section 3.4 for an explanation of assembling loads.

PARAMETERS:

CHANGE	Changes a previously created location string for the superelement being included. Not to be confused with the USE command; see below.
CREATE	Creates a location string for the superelement being included.
USE	Modifies location strings for superelements forming the superelement being included. For example, if the current superelement assembly is a fourth level superelement and the superelement being included is a third level superelement, then the command modifies location strings for the second and first level superelements forming the third level superelement.
DELETE	Deletes a location string for the superelement being included.
oldloc	Previously created location string to be changed or deleted.
newloc	New location string replacing the previous one.
loc	Location string assigned to the superelement being included.
refloc	Location string(s) to be modified. Wild-cards may be used; see notes below.
modloc	The modified location string(s). Wild-cards may be used; see notes below.

NOTES:

The location strings are limited to eight characters.

The LOCATION USE command allows modifying location strings by use of wild-cards. The following modifications are allowed (interpret the single characters in the examples as several characters):

refloc	modloc	
*	X	replaces all strings by X
*A	X	replaces all strings ending with A by X
A*	X	replaces all strings beginning with A by X

A*	X*	replaces A by X in all strings beginning with A
*A	*X	replaces A by X in all strings ending with A
A	*X*	replaces A by X in any string containing A
*	*X	appends X to all strings
A*	A*X	appends X to all strings beginning with A
*A	*AX	appends X to all strings ending with A
A*B*C	X*Y*Z	replaces the characters A, B and C in strings containing these characters (e.g. ABC, AB1C, A12B34C) by X, Y and Z, respectively.

INCLUDE supno MIRROR

...	MIRROR	YZ-PLANE
		ZX-PLANE
		XY-PLANE

PURPOSE:

The sub-command mirrors the superelement being included about one of the three planes defined by the axes of the superelement assembly.

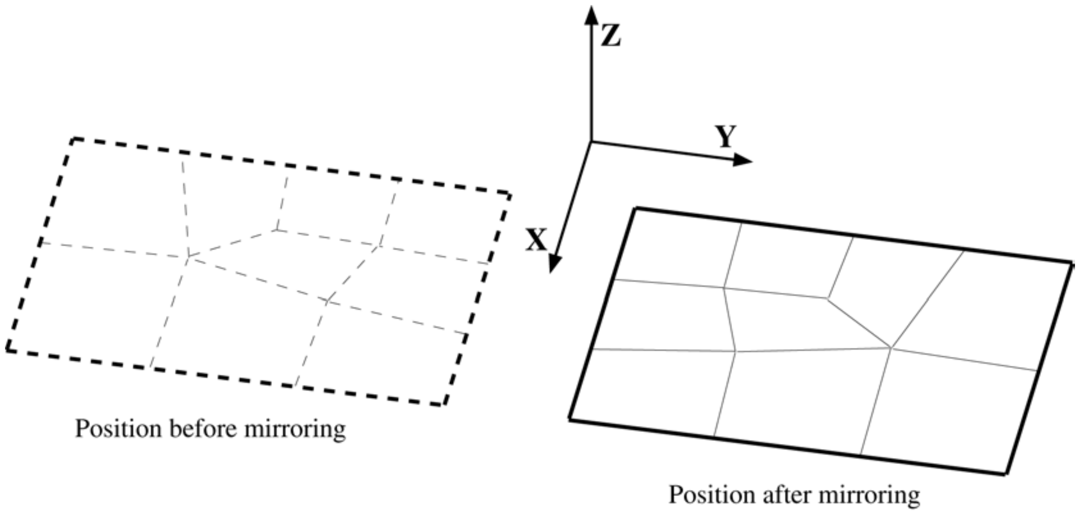


Figure 5.6 MIRROR about ZX-PLANE

NOTES:

It is the current position of the superelement being included that is mirrored.

Mirroring a superelement involves that the superelement occurrence gets a left-handed coordinate system. The results must then be interpreted in such a coordinate system.

Mirroring a superelement twice (e.g. by also mirroring the superelement assembly when this in turn is included in yet a higher level superelement) involves that the superelement occurrence regains a right-handed coordinate system.

INCLUDE supno NOPRINT-CHECK-INCLUDE

...	NOPRINT-CHECK-INCLUDE

PURPOSE:

The sub-command compares the supernodes of the superelement being included and the nodes of the current superelement assembly. It has the same purpose and functionality as the NOPRINT-CHECK-INCLUDE sub-command except for that the table over matching nodes is omitted. Only the summary information is given; see Figure 5.3.

INCLUDE supno PERFORM-INCLUDE

...	PERFORM-INCLUDE

PURPOSE:

The sub-command concludes the process of including a superelement in an assembly. It is given subsequently to the sub-command NOPRINT-CHECK-INCLUDE (or CHECK-INCLUDE).

The following table is produced:

```
SUPER ELEMENT INCLUDED
    SUPER ELEMENT TYPE:              11
    SUPER ELEMENT INDEX:             3
    LEVEL:                           1
    NO. OF INTERNAL NODES:           2
    NO. OF SUPER NODES MATCHING:     3
    NO. OF SUPER NODES NOT MATCHING: 3
    NO. OF NODES:                    8
INTO SUPER ELEMENT ASSEMBLY
    SUPER ELEMENT TYPE:              21
    SUPER ELEMENT INDEX:             1
    LEVEL:                           2
    NO. OF OLD NODES:                9
    NO. OF NEW NODES:                3
    NO. OF NODES:                    12
```

NOTES:

The command is the mandatory final step in including a superelement in an assembly.

INCLUDE supno POSITION

...	POSITION	NODE	supno	index	nodeno	*6
		COORDINATES	x	y	z	

PURPOSE:

The sub-command positions the superelement by referring to three points or nodes of the superelement assembly and the corresponding three points or nodes of the superelement being included. The three points/ nodes of the assembly are given first. The two sets of three points/nodes must form a triangle and they must be congruent.

If the COORDINATE alternative is chosen the point does not have to correspond to a node. The coordinates are given in the coordinate systems of the assembly and superelement being included, respectively.

The POSITION sub-command cannot be used if transformations have already been specified for the superelement being included. Use the RESET-T-MATRIX sub-command in such case.

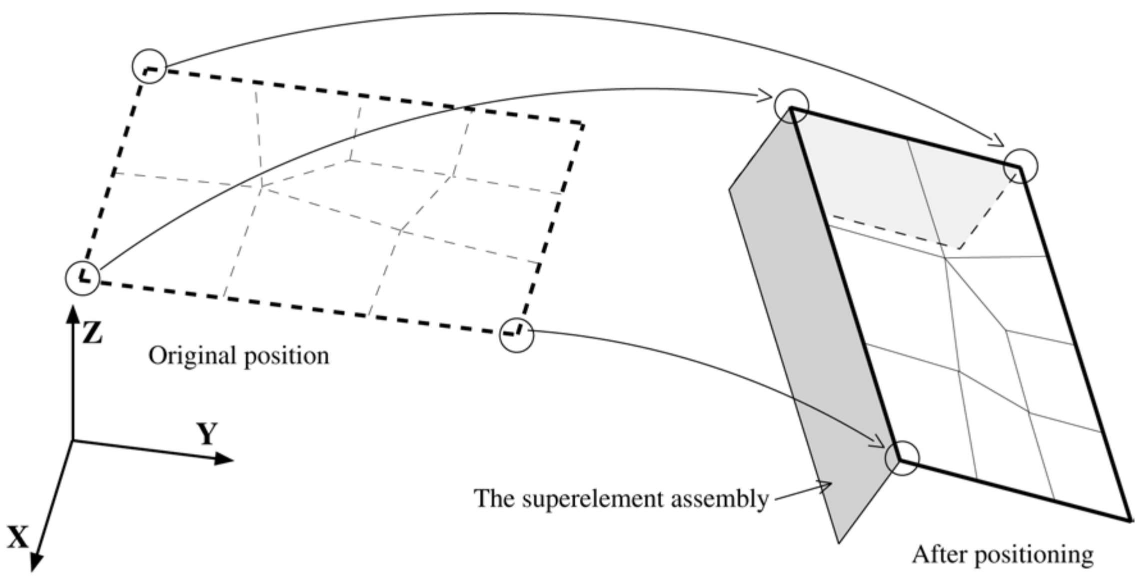


Figure 5.7 POSITION by two sets of three nodes or points

PARAMETERS:

NODE	Refer to a node triplet.
supno index nodeno	The node number triplet.
COORDINATE	Refer to a point by using coordinates.
x y z	The point coordinates.

INCLUDE supno PRINT-T-MATRIX / PRINT-INV-T-MATRIX

...	PRINT-T-MATRIX
	PRINT-INV-T-MATRIX

PURPOSE:

The sub-commands print the transformation matrix of the superelement being included. This 3 by 4 matrix is an accumulation of all translations, rotations and mirrorings given for the superelement.

The first three columns of the transformation matrix (a 3 by 3 matrix) constitute the cosine matrix (rotations) between the coordinate systems of the superelement being included and the superelement assembly. The fourth column describe the translations between the systems. The conversion of coordinates from one system to the other is done by adding a row of zeros to the transformation matrix to make it a 4 by 4 matrix and adding a fourth term being equal to 1 to the coordinate vectors as follows:

$$\begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix} = \begin{bmatrix} T_{11} & T_{12} & T_{13} & T_{14} \\ T_{21} & T_{22} & T_{23} & T_{24} \\ T_{31} & T_{32} & T_{33} & T_{34} \\ 0 & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix}$$

PARAMETERS:

PRINT-T-MATRIX

The transformation matrix is printed. The relation between the coordinate systems of the superelement being included and the superelement assembly is:

$\mathbf{C} = \mathbf{T} \times \mathbf{C}'$

Where:

C is the coordinates in the assembly coordinate system and
C′ is the coordinates in the superelement’s coordinate system.

PRINT-INV-T-MATRIX

The inverted transformation matrix ($\mathbf{T}^{-1}$) is printed.

INCLUDE supno RESET-T-MATRIX

...	RESET-T-MATRIX

PURPOSE:

The sub-command resets the transformation matrix containing the accumulated translations, rotations and mirrorings of the superelement being included. This means that the superelement being included is brought back to its original position with its coordinate system overlapping the coordinate system of the superelement assembly. It is then ready for new transformations.

INCLUDE supno ROTATE

<table>
<tr><td rowspan="8">...</td><td rowspan="8">ROTATE</td><td rowspan="3">GLOBAL-AXIS</td><td>X-AXIS</td><td colspan="5" rowspan="3">degrees</td></tr>
<tr><td>Y-AXIS</td></tr>
<tr><td>Z-AXIS</td></tr>
<tr><td rowspan="3">OBJECT-AXIS</td><td>X-AXIS</td><td colspan="5" rowspan="3">degrees</td></tr>
<tr><td>Y-AXIS</td></tr>
<tr><td>Z-AXIS</td></tr>
<tr><td rowspan="2">ARBITRARY-AXIS</td><td>NODE</td><td>supno</td><td>index</td><td>nodeno</td><td rowspan="2">*2</td><td rowspan="2">degrees</td></tr>
<tr><td>COORDINATES</td><td>x</td><td>y</td><td>z</td></tr>
</table>

PURPOSE:

The sub-command rotates the superelement being included an angle about a specified axis.

A positive angle is defined by the right hand rule.

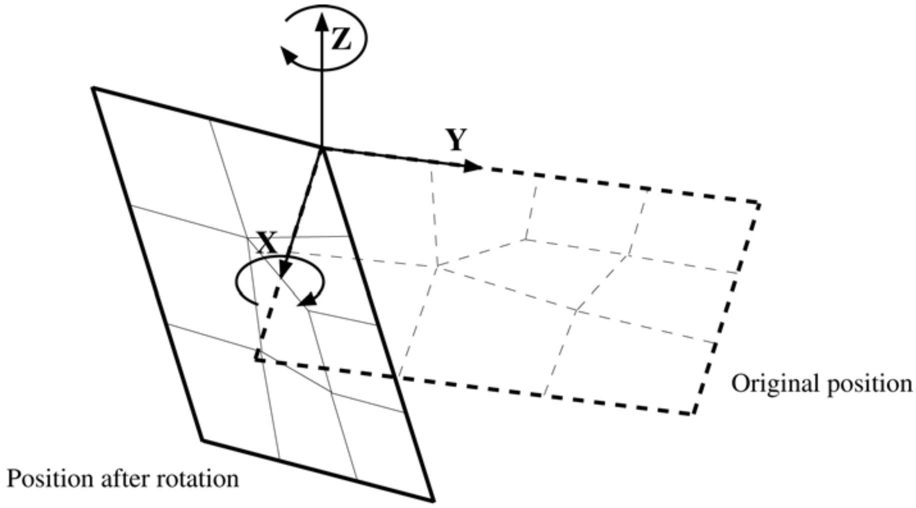


Figure 5.8 ROTATE about global axes

PARAMETERS:

GLOBAL-AXIS	The superelement being included rotates about one of the coordinate axes of the superelement assembly.
OBJECT-AXIS	The superelement being included rotates about one of the coordinate axes of the superelement itself.

X-AXIS	The axis of rotation.
Y-AXIS	The axis of rotation.
Z-AXIS	The axis of rotation.
ARBITRARY-AXIS	The superelement being included rotates about an axis defined by two points. The axis points from the first to the second point which then determines the positive direction of rotation (the right hand rule). The points are given by referring to nodes or by giving coordinates in the coordinate system of the superelement assembly.
NODE	Refer to a node triplet.
supno index nodeno	The node number triplet. This node must be a part of the current assembly, i.e. belong to a superelement that has previously been included.
COORDINATE	Refer to a point by using coordinates.
x y z	The point coordinates.
degrees	Rotation given in degrees.

INCLUDE supno TRANSLATE

...	TRANSLATE	dx	dy	dz

PURPOSE:

The sub-command translates the superelement being included along the axes of the superelement assembly.

PARAMETERS:

dx dy dz	The translations in X, Y and Z.

LABEL

<table>
<tr><td rowspan="11">LABEL</td><td colspan="4">BOUNDARY-CONDITION-SYMBOLS</td></tr>
<tr><td colspan="4">COUPLED-NODES</td></tr>
<tr><td rowspan="5">NODE-NUMBERS</td><td>EXTERNAL-NODE-NUMBER</td><td>supno</td><td>index</td></tr>
<tr><td colspan="3">INTERNAL-NODE-NUMBER</td></tr>
<tr><td rowspan="3">NODE-NUMBER-TRIPLET</td><td>supno</td><td>index</td></tr>
<tr><td colspan="2">ONE-NODE-NUMBER-TRIPLET</td></tr>
<tr><td colspan="2">ALL-NODE-NUMBER-TRIPLETS</td></tr>
<tr><td rowspan="2">NODE SYMBOLS</td><td colspan="3">ALL-NODES</td></tr>
<tr><td colspan="3">SUPER-NODES-ONLY</td></tr>
<tr><td colspan="4">NON-COUPLED-NODES</td></tr>
<tr><td colspan="4">ORIGIN-SYMBOL</td></tr>
</table>

PURPOSE:

The command adds (labels) boundary condition symbols, node numbers, etc. to the display. The labels are shown until a new display is made; the label command may then be re-entered. The size of the symbols are adjusted by the SET GRAPHICS SIZE-SYMBOLS command. The symbols used are shown in Figure 5.9.

PARAMETERS:

BOUNDARY-CONDITION-SYMBOLS	Add symbols showing fixations of d.o.f.s.
COUPLED-NODES	Add numbers to the display telling how many first level superelements there are coupled to each node. The numbers are only given for nodes where two or more first level superelements are coupled, i.e. the number will always be ≥2. Also see the NON-COUPLED-NODES alternative.
NODE-NUMBERS	Add node numbers. A choice must be made between various alternatives. To understand these alternatives; see Section 3.2.6 about node numbers.
EXTERNAL-NODE-NUMBER	Add only the node number of a given first level superelement.
supno index	Superelement number and index of a first level superelement.
INTERNAL-NODE-NUMBER	Add only the internal number of the current superelement assembly (normally, this is of little interest to the user).
NODE-NUMBER-TRIPLET	Add one or all node number triplets — the full and unique references to nodes (see Section 3.2.5 about triplets).

supno index	Select one of the possibly several triplets by giving superelement number and index.
ONE-NODE-NUMBER-TRIPLET	Only one of the possibly several triplets is shown. The program automatically selects which of the triplets to show.
ALL-NODE-NUMBER-TRIPLETS	All triplets are shown reflecting the fact that the nodes have one triplet for each first level superelement connected.
NODE-SYMBOLS	Add node symbols.
ALL-NODES	All node symbols are shown.
SUPER-NODES-ONLY	Only supernode symbols are shown.
NON-COUPLED-NODES	Add the number 1 to the display for all nodes to which only a single first level superelement is coupled. There will be no label for nodes where two or more first level superelements are coupled. This alternative is the complement to COUPLED-NODES.
ORIGIN-SYMBOL	Add a symbol showing where the origin is located.

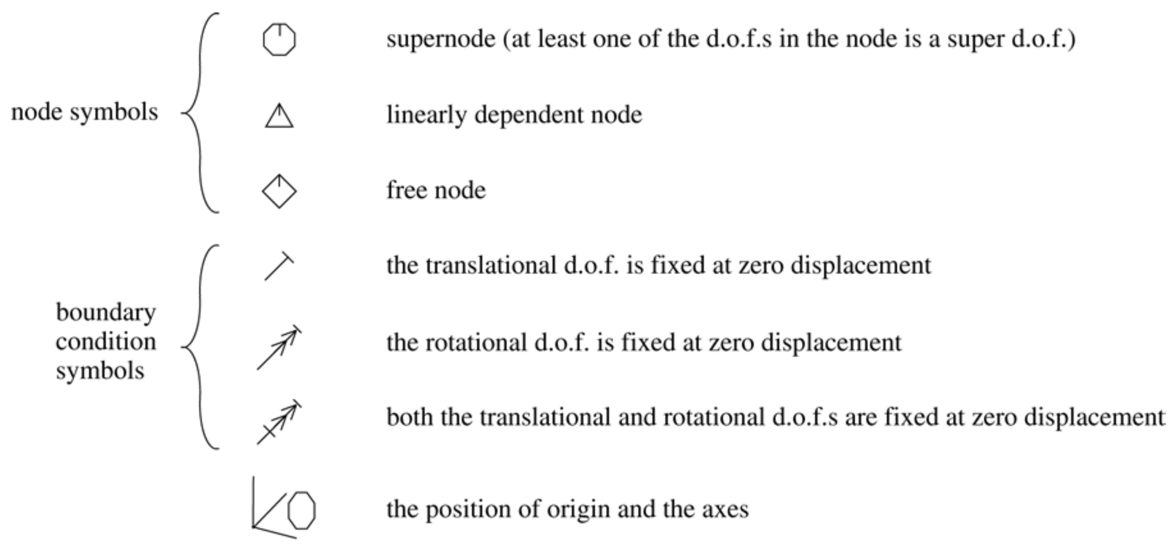


Figure 5.9 Symbols produced by the LABEL command

LINEAR-DEPENDENCY

<table>
<tr><td rowspan="3">LINEAR-DEPENDENCY</td><td>GENERAL-NODE-DEPENDENCY</td><td rowspan="3">...</td></tr>
<tr><td>TWO-NODE-DEPENDENCY</td></tr>
<tr><td>END</td></tr>
</table>

PURPOSE:

The command defines the displacements of selected nodes to be linearly dependent of displacements of other selected nodes. See also Section 3.6.

The GENERAL-NODE-DEPENDENCY option couples *any d.o.f. of a node* (the dependent d.o.f.) to *any other d.o.f.s of any other nodes* (the independent d.o.f.s). The TWO-NODE-DEPENDENCY option couples *all d.o.f.s of a given node* to the *corresponding d.o.f.s of two other nodes*.

Linear dependencies involves that the dependent d.o.f.s get the boundary condition LINEAR and the independent d.o.f.s get the boundary condition SUPERL (super due to linear dependency). (A SUPERL d.o.f. will appear in the next level superelement in the same way as a SUPER d.o.f.) There are certain rules as concerns the boundary condition of a d.o.f. before and after the definition of a linear dependency and whether the linear dependency can at all be defined. Table 5.1 describes these rules for the dependent d.o.f. and Table 5.2 for the independent d.o.f. A violation of the rules involves that the linear dependency is not accepted.

Table 5.1 Rules for boundary condition of a dependent d.o.f.

Boundary cond. before	Boundary cond. after	Comment
FREE	LINEAR	OK
FIXED	LINEAR	Warning: the boundary condition is changed
PRESC.	-	Illegal, a prescribed cannot be made dependent
LINEAR	LINEAR	OK (implies adding dependency of new d.o.f.s)
SUPER	LINEAR	Warning: the boundary condition is changed
SUPERL	-	Illegal, linear dependency cannot propagate

Table 5.2 Rules for boundary condition of an independent d.o.f.

Boundary cond. before	Boundary cond. after	Comment
FREE	SUPERL	OK if FORCE-INTO-SUPER is used
FIXED	SUPERL	OK if FORCE-INTO-SUPER is used
PRESC.	-	Illegal, cannot be changed to super
LINEAR	-	Illegal, d.o.f. is not independent

Table 5.2 Rules for boundary condition of an independent d.o.f.

SUPER	SUPERL	OK
SUPERL	SUPERL	OK

LINEAR-DEPENDENCY GENERAL-NODE-DEPENDENCY

...	GENERAL-NODE-DEPENDENCY	dep-node-triplet	...

...	{	dep-dof	{	indep-node-triplet	{	indep-dof	beta	}*	}*	}*

PURPOSE:

The command defines general linear dependency between nodes. See also Section 3.6.

The dependency is defined by selecting a single d.o.f. of a node to be dependent of any other d.o.f.s of any other nodes. You may keep defining several d.o.f.s of a given node to be dependent. And for each of these dependent d.o.f. you may keep selecting independent (governing) nodes. And, finally, for each of these independent nodes you may keep selecting d.o.f.s to govern, with a factor, the displacement of the dependent d.o.f.

Note: Alternatively to defining the independent d.o.f. as super prior to this command it may be made super within this command by the FORCE-...-INTO-SUPER option. Using this option for a d.o.f. that is already super has no consequence.

PARAMETERS:

dep-node-triplet	Node number triplet (supno index nodeno) of the dependent node.
dep-dof	D.o.f. to be dependent, legal specifications are:
	X, Y and Z: Translations in X-, Y- and Z-directions
	R-X, R-Y and R-Z: Rotations about the X-, Y- and Z-directions
indep-node-triplet	Node number triplet (supno index nodeno) of an independent node.
indep-dof	The independent d.o.f., legal specifications are:
	X, Y and Z: Translations in X-, Y- and Z-directions
	R-X, R-Y and R-Z: Rotations about the X-, Y- and Z-directions
	FORCE-X-INTO-SUPER and similar for Y and Z
	FORCE-R-X-INTO-SUPER and similar for R-Y and R-Z
	If the independent d.o.f. has not previously been defined as SUPERL (or SUPER) then use the appropriate of the FORCE-...-INTO-SUPER alternatives to force it into being SUPERL.
beta	Linear dependency factor.

LINEAR-DEPENDENCY TWO-NODE-DEPENDENCY

...	TWO-NODE-DEPENDENCY	{	dep-node-triplet	...

<table>
<tr><td rowspan="2">...</td><td colspan="2">indep-node1-triplet</td><td rowspan="2">...</td></tr>
<tr><td>FORCE-INTO-SUPER</td><td>indep-node1-triplet</td></tr>
</table>

<table>
<tr><td rowspan="2">...</td><td colspan="2">indep-node2-triplet</td><td rowspan="2">beta</td><td rowspan="2">}*</td></tr>
<tr><td>FORCE-INTO-SUPER</td><td>indep-node2-triplet</td></tr>
</table>

PURPOSE:

The command defines linear dependency for a node on two other nodes. All d.o.f.s of the dependent node are dependent of the corresponding d.o.f.s of the first independent node by the factor beta and the second independent node by the factor (1 - beta). See also Section 3.6.

Note that alternatively to defining the independent node as super prior to this command it may be made super within this command by the FORCE-INTO-SUPER option. Using this option for a node already being super has no consequence.

PARAMETERS:

dep-node-triplet	Node number triplet (supno index nodeno) of the dependent node.
indep-node1-triplet	Node number triplet (supno index nodeno) of the first independent node.
FORCE-INTO-SUPER	Using this option implies that the d.o.f.s of the independent nodes are forced into SUPERL if they are not SUPER or SUPERL already.
indep-node2-triplet	Node number triplet (supno index nodeno) of the second independent node.
beta	Linear dependency factor.

LOAD

<table>
<tr><td rowspan="3">LOAD</td><td>ASSEMBLY</td><td rowspan="3">...</td></tr>
<tr><td>COMBINATION</td></tr>
<tr><td>NODE</td></tr>
</table>

PURPOSE:

The command defines loads for the current superelement which must be a second or higher level superelement.

The three alternatives are described in more detail in the following.

PARAMETERS:

ASSEMBLY	This option allows assembling loads directly to the top level. See Section 3.4 for more information on this.
COMBINATION	This option creates a load for a superelement assembly by combining loads of its included superelements.
NODE	This option creates nodal loads.

LOAD ASSEMBLY

<table>
<tr><td rowspan="2">...</td><td rowspan="2">ASSEMBLY</td><td rowspan="2">glc-top</td><td>INCLUDE-LOAD</td><td>refname.refloc</td><td>local-load-case</td><td>factor</td></tr>
<tr><td colspan="4">END</td></tr>
</table>

PURPOSE:

The command defines loads for the current superelement assembly (normally the top level superelement) by combining loads of lower level superelements (normally 1st level superelements). The lower level superelements are referred to by names and location strings. Load combinations are automatically created for all intermediate level superelements. The use of the command is explained in Section 3.4.

The load combinations created for the current superelement assembly and all intermediate level superelements may be verified by the PRINT LOAD command.

PARAMETERS:

glc-top	Global load case number of the superelement assembly.
INCLUDE-LOAD	Include in the global load case the following lower level superelement loads.
refname.refloc	Refers to superelement occurrences. refname is the name of the lower level superelement. refloc is the location string of the superelement occurrence. refname and refloc are given as indicated: separated by a punctuation mark only. The asterisk (*) may be used as wild-card. In the following examples the characters A, B, X and Y should be interpreted as any number of characters (names and location strings are both limited to 8 characters): *.* are all lower level superelements and all location strings of these. I.e. absolutely all superelement occurrences at any level for which names and location strings have been defined. *A.*X are all lower level superelements with names ending with A and all location strings of these ending with X. A*.X* are all lower level superelements with names beginning with A and all location strings of these beginning with X. A*B*.*X*Y are all lower level superelements with names beginning with A and containing B and all location strings of these containing X and ending with Y.
llc	(Local) load case number of the lower level superelements being referred to.
factor	Factor to apply to the (local) load case.

LOAD COMBINATION

...	COMBINATION	...

<table>
<tr><td rowspan="6">...</td><td colspan="4" rowspan="3">glc</td><td rowspan="2">{</td><td rowspan="2">supno</td><td rowspan="2">index</td><td>{ llc</td><td>factor</td><td>}*</td><td colspan="2" rowspan="2">}*</td></tr>
<tr><td colspan="3">END</td></tr>
<tr><td colspan="8">END</td></tr>
<tr><td rowspan="2">GROUP</td><td rowspan="2">lowglc</td><td rowspan="2">higlc</td><td rowspan="2">step</td><td>{</td><td>supno</td><td>index</td><td>[STEP]</td><td>lowllc</td><td>[incr]</td><td>factor</td><td>}*</td></tr>
<tr><td colspan="8">END</td></tr>
<tr><td colspan="12">END</td></tr>
</table>

PURPOSE:

The command defines loads for the current superelement by combining loads of the included superelements. The current superelement must be a second or higher level superelement. The loads may be combined one-by-one (explicitly) or a group of loads may be combined. See Section 3.3 for an explanation of the principles of combining loads.

Several superelement occurrences (superelement number and index) and several (local) load cases belonging to the superelement occurrences may contribute to a single (global) load case of the current superelement.

The (local) load cases (llc) of included first level superelements need not exist prior to giving this command, warnings are then given saying that the input is accepted even though the local load cases are unknown. Prior to running the analysis, however, the local load cases must have been created. Read the note in Section 3.3.4 on this.

The load combinations may be verified by the PRINT LOAD command.

PARAMETERS:

glc	A single (global) load case number to be defined for the current superelement.
supno index	Superelement number and index of an included superelement.
llc	(Local) load case number of the included superelement contributing to glc.
factor	Factor to apply to the (local) load case.
GROUP	A group of (global) load cases is to be defined.
lowglc higlc step	The lowest and highest (global) load case numbers and the step (increment) in numbering. An example: 1 5 2 will define loads 1, 3 and 5.
STEP	A step (increment) in numbering of the (local) load cases of the included superelements is to be given; see incr below. If this command is omitted then incr is omitted as well.

lowllc	The lowest (local) load case number of the included superelement contributing to glc.
incr	The step (increment) in (local) load case numbering.

LOAD NODE

...	NODE	lc	FORCE	...
			PRESCRIBED-ACCELLERATION	
			PRESCRIBED-DISPLACEMENT	

...	SELECT	select-nodes	...
	TAGGED		
	UNTAGGED		
	END		

...	GLOBAL		fx	fy	fz	mx	my	mz	...
	TRANSFORMTAION	trano							

...	IMAGINARY-COMPLEX	ifx	ify	ifz	imx	imy	imz
	PHASE-COMPLEX	pfx	pfy	pfz	pmx	pmy	pmz
	END						

PURPOSE:

The command defines nodal loads for the current superelement. The current superelement must be a second or higher level superelement.

The nodal loads are of the following types:

- Forces and moments, the FORCE alternative
- Prescribed displacements
- Prescribed acceleration (relevant for dynamic analysis only)

Prior to giving prescribed displacements and accelerations the corresponding nodes must previously have been given the PRESCRIBED boundary condition; see the BOUNDARY command. Alternatively to all six only selected d.o.f.s may be given prescribed displacements/accelerations. The PRESCRIBED boundary condition must then have been defined only for the relevant d.o.f.s. Note that even if only selected d.o.f.s have prescribed boundary condition values must be entered in the LOAD NODE command for all six d.o.f.s. The values given for the non-prescribed d.o.f.s are discarded.

The nodal loads may be verified by the PRINT LOAD command.

PARAMETERS:

lc	A single load case number to be defined for the current superelement.

FORCE	The load is a force and/or moment.
PRESCRIBED-ACCELERATION	The load is a prescribed acceleration.
PRESCRIBED-DISPLACEMENT	The load is a prescribed displacement.
SELECT	Nodes are to be selected now.
select-nodes	Select nodes; see Section 5.1.
TAGGED	Refers to previously selected (tagged) nodes; see the TAG/UNTAG commands.
UNTAGGED	Refers to all but the previously selected (tagged) nodes; see the TAG/UNTAG commands.
GLOBAL	The load is specified in the coordinate system of the superelement.
TRANSFORMATION	The load is specified in a rotated coordinate system.
trano	Transformation reference number previously defined by the TRANSFORMATION command.
fx fy fz mx my mz	Real components of the forces/moments or prescribed displacements/accelerations.
IMAGINARY-COMPLEX	The load is complex and the imaginary components are to be given.
ifx ify ifz imx imy imz	Imaginary components of the forces/moments or prescribed displacements/accelerations. Prescribed rotations are given in radians.
PHASE-COMPLEX	The load is complex and the phase angle components are to be given.
pfx pfy pfz pmx pmy pmz	Phase angle components in degrees of the forces/moments or prescribed displacements/accelerations.
END	Give END rather IMAGINARY-COMPLEX or PHASE-COMPLEX to conclude the command and make the load non-complex.

NAME

NAME	CREATE	name

PURPOSE:

The command creates a name for a superelement. It is used in connection with the LOAD ASSEMBLY command. See Section 3.4 for an explanation of assembling loads.

PARAMETERS:

name	Name given to the current first or higher level superelement. It is a string of maximum 8 characters.

OPTIMIZE

OPTIMIZE	supno	BANDWIDTH
		OPTIONS
		PROFILE

PURPOSE:

The command optimises (rearranges) the internal node numbering of a higher level superelement. The objective of this is to reduce the bandwidth or profile of the stiffness matrix of the superelement thereby reducing the time required to solve the equation system of the superelement (this is done in the analysis program, e.g. Sestra).

Note: The node numbers seen by the user, the node number triplets, are not affected by this operation.

The superelement cannot be a first level superelement. First level superelements must be optimised prior to being read into Presel. See Prefem or Preframe on this.

If a superelement is to be optimised it must be done prior to being included in a higher level superelement assembly.

See Section 3.10 for more information.

PARAMETERS:

supno	Superelement number.
BANDWIDTH	The internal node numbering is optimised to reduce the bandwidth of the stiffness matrix. This is the preferred option for Sestra.
OPTIONS	This alternative is currently irrelevant.
PROFILE	The internal node numbering is optimised to reduce the profile of the stiffness matrix. This alternative is currently irrelevant.

PLOT

<table>
<tr><td rowspan="2">PLOT</td><td>AS-LAST-DISPLAY</td><td rowspan="2">text</td><td rowspan="2">*4</td><td rowspan="2">page-size</td></tr>
<tr><td>choices</td></tr>
</table>

Where ‘choices’ in the command syntax above represents all of the following:

<table>
<tr><td rowspan="3">...</td><td rowspan="3">Mesh on plot?
YES or NO</td><td rowspan="3">Origin symbol?
YES or NO</td><td rowspan="3">Boundary conditions?
YES or NO</td><td>ALL-NODES</td><td rowspan="3">...</td></tr>
<tr><td>SUPER-NODES-ONLY</td></tr>
<tr><td>NONE</td></tr>
</table>

<table>
<tr><td rowspan="8">...</td><td colspan="3">COUPLED-NODES</td><td rowspan="8">...</td></tr>
<tr><td colspan="3">NON-COUPLED-NODES</td></tr>
<tr><td>EXTERNAL-NODE-NUMBER</td><td>supno</td><td>index</td></tr>
<tr><td colspan="3">INTERNAL-NODE-NUMBER</td></tr>
<tr><td rowspan="3">NODE-NUMBER-TRIPLET</td><td>supno</td><td>index</td></tr>
<tr><td colspan="2">ONE-NODE-NUMBER-TRIPLET</td></tr>
<tr><td colspan="2">ALL-NODE-NUMBER-TRIPLETS</td></tr>
<tr><td colspan="3">NONE</td></tr>
</table>

PURPOSE:

The command reproduces the display on a plot file (or sends it directly to the printer in case of WINDOWS-PRINTER format of the plot file).

Unless the AS-LAST-DISPLAY option is chosen the command poses the following questions:

- Include the mesh on the plot? Answer YES or No.
- Include a symbol for the origin of the superelement coordinate system? Answer YES or NO.
- Include the boundary conditions on the plot? Answer YES or NO.
- Include node symbols on the plot? Answer ALL-NODES, SUPER-NODES-ONLY or NONE.
- Include node numbers on the plot? Choose between COUPLED-NODES, NON-COUPLED-NODES, EXTERNAL-NODE-NUMBER, INTERNAL-NODE-NUMBER, NODE-NUMBER-TRIPLET and NONE. See explanations below.

Whether the AS-LAST-DISPLAY option is chosen or not the PLOT command is concluded by:

- Enter four lines of text. Each text line is limited to 24 characters and must be enclosed in apostrophes if containing blanks. For example: 'THIS IS A TEXT'. These lines are reproduced on the plot.

- Finally the page size is given. This is only relevant for the SESAM-NEUTRAL plot format; see the SET PLOT command. For other plot formats give any parameter, e.g. the default A4.

The date and time is also reproduced on the plot together with scale, superelement number and the superelement level. The scale is based on the assumption that metres are used as unit for the coordinates.

PARAMETERS:

AS-LAST-DISPLAY	The screen display with current labelling and other display information is plotted.
text	The screen display with current labelling and other display information is plotted.
page-size	The page size. Choose between A1, A2, A3, A4 and A5. A4 is the default choice.
ALL-NODES	All node symbols are shown.
SUPER-NODES-ONLY	Only supernode symbols are shown.
COUPLED-NODES	Add numbers to the plot telling how many first level superelements there are coupled to each node. The numbers are only given for nodes where to or more first level superelements are coupled, i.e. the number will always be ≥2. Also see the NON-COUPLED-NODES alternative.
NON-COUPLED-NODES	Add the number 1 to the plot for all nodes to which only a single first level superelement is coupled. There will be no label for nodes where two or more first level superelements are coupled. This alternative is the complement to COUPLED-NODES.
EXTERNAL-NODE-NUMBER	Add only the node number of a given first level superelement.
supno index	Superelement number and index of a first level superelement.
INTERNAL-NODE-NUMBER	Add only the internal number of the current superelement assembly (normally, this is of little interest to the user).
NODE-NUMBER-TRIPLET	Add one or all node number triplets — the full and unique references to nodes (see Section 3.2.5 about triplets).
ONE-NODE-NUMBER-TRIPLET	Only one of possibly several triplets is shown. The program automatically selects which of the triplets to show.
ALL-NODE-NUMBER-TRIPLETS	All triplets are shown reflecting the fact that the nodes have one triplet for each first level superelement connected.

PRINT

<table>
<tr><td rowspan="14">PRINT</td><td colspan="3">supno</td></tr>
<tr><td colspan="3">ALL</td></tr>
<tr><td rowspan="2">CPU-TIME-ESTIMATES-IN-REDUCTION</td><td colspan="2">supno</td></tr>
<tr><td colspan="2">ALL</td></tr>
<tr><td colspan="3">ELEMENT</td></tr>
<tr><td>LOAD</td><td colspan="2">...</td></tr>
<tr><td>NODE</td><td colspan="2">...</td></tr>
<tr><td colspan="3">OVERVIEW-OF-SUPER-ELEMENTS</td></tr>
<tr><td colspan="3">STATUS</td></tr>
<tr><td>SUPER-ELEMENT-HIERARCHY</td><td>supno</td><td>index</td></tr>
<tr><td rowspan="3">TRANSFORMATION</td><td colspan="2">trano</td></tr>
<tr><td colspan="2">ALL</td></tr>
<tr><td colspan="2">END</td></tr>
<tr><td colspan="3">END</td></tr>
</table>

PURPOSE:

The command prints data in tables on screen and to file. The destination depends on what to print: e.g. PRINT ALL goes to file whereas PRINT STATUS goes to the screen. The SET PRINT DESTINATION command overrules these default destinations. Long prints are broken into several sub-tables, each limited to a certain number of lines. When printing to screen in interactive mode enter CONTINUE to print the next sub-table (or END to stop). The SET PRINT PAGESIZE command changes the number of lines contained in each sub-table.

PARAMETERS:

supno	Print to file all data for the superelement supno.
ALL	Print to file all data for all superelements.
CPU-TIME-ESTIMATES-IN-REDUCTION	Print on screen CPU time estimates for the reduction. Select a single or all superelements. See example print in Section 3.8.
ELEMENT	Print on screen information on superelements included in the current superelement. See example print in Section 3.8.
LOAD	Print on screen information on loads. The command is described in detail in the following.

NODE	Print on screen information on nodes. The command is described in detail in the following.
OVERVIEW-OF-SUPER-ELEMENTS	Print on screen an overview of all superelements. See example print in Section 3.8.
STATUS	Print on screen model and log file names and current tolerances.
SUPER-ELEMENT-HIERARCHY	Print on screen the superelement hierarchy up to the given superelement (supno index). See example in Section 3.8.
TRANSFORMATION	Print on screen information transformations defined for the current superelement. Select one or all transformations. Give END to stop printing transformations.

PRINT LOAD

<table>
<tr><td rowspan="9">...</td><td rowspan="9">LOAD</td><td rowspan="5">lc</td><td colspan="2">ALL-TYPES-NODES-COMBINATIONS</td></tr>
<tr><td colspan="2">COMBINATIONS</td></tr>
<tr><td>NODE-FORCE</td><td rowspan="2">...</td></tr>
<tr><td>NODE-PRESCRIBED</td></tr>
<tr><td colspan="2">END</td></tr>
<tr><td colspan="3">ALL-LOADCASES</td></tr>
<tr><td rowspan="3">OVERVIEW</td><td colspan="2">lc</td></tr>
<tr><td colspan="2">ALL-LOADCASES</td></tr>
<tr><td colspan="2">END</td></tr>
</table>

<table>
<tr><td rowspan="4">...</td><td>SELECT</td><td>select-nodes</td></tr>
<tr><td colspan="2">TAGGED</td></tr>
<tr><td colspan="2">UNTAGGED</td></tr>
<tr><td colspan="2">END</td></tr>
</table>

PURPOSE:

The command prints loads defined for the current superelement.

PARAMETERS:

lc	Load case number.
ALL-TYPES-NODES-COMBINATIONS	Print all types of loads for the selected load case number.
COMBINATIONS	Print only the load combinations belonging to the selected load case number.
NODE-FORCE	Print only the nodal forces, for selected nodes, belonging to the selected load case number.
NODE-PRESCRIBED	Print only the nodal prescribed displacements and accelerations, for selected nodes, belonging to the selected load case number.
SELECT	Nodes are to be selected now.
select-nodes	Select nodes; see Section 5.1.
TAGGED	Refers to previously selected (tagged) nodes; see the TAG/UNTAG commands.

UNTAGGED	Refers to all but the previously selected (tagged) nodes; see the TAG/UNTAG commands.
ALL-LOADCASES	Print all information for all load cases.
OVERVIEW	Print an overview for a selected load case or for all load cases.

PRINT NODE

<table>
<tr><td rowspan="4">...</td><td rowspan="4">NODE</td><td>BOUNDARY-CONDITIONS</td><td rowspan="4">...</td><td>SELECT</td><td>select-nodes</td></tr>
<tr><td>COORDINATES</td><td colspan="2">TAGGED</td></tr>
<tr><td>LINEAR-DEPENDENCY</td><td colspan="2">UNTAGGED</td></tr>
<tr><td>NUMBER</td><td colspan="2">END</td></tr>
</table>

PURPOSE:

The command prints nodal data for the current superelement.

Note that you may change the print format for real numbers (FORTRAN E, F or G formats) by the SET PRINT FORMAT command. E-format is the default choice.

PARAMETERS:

BOUNDARY-CONDITIONS — Print boundary conditions for selected nodes. It is possible to switch between text and digits for boundary condition codes by the SET PRINT TABLE NODE-BOUNDARY-TABLE command. The boundary condition codes used in the print table are described in Table 5.3.

Table 5.3 Boundary condition codes of individual d.o.f. in print table

Digit	Text	Boundary condition of d.o.f.
-1	X	d.o.f. does not exist (node has reduced number of d.o.f.s.)
0	(blank)	free
1	FIXED	fixed at zero displacement
2	PRESC.	prescribed displacement
3	LINEAR	linearly dependent of some other d.o.f.(s)
4	SUPER	super d.o.f.
100	SUPERL	super d.o.f. due to linear dependency

COORDINATES — Print coordinates for selected nodes. See example print in Section 3.8.

LINEAR-DEPENDENCY — Print linear dependencies for selected nodes.

NUMBER — Print the node numbers of selected nodes. The table shows the node number triplets along with the internal node numbers.

SELECT — Nodes are to be selected now.

select-nodes	Select nodes; see Section 5.1.
TAGGED	Refers to previously selected (tagged) nodes; see the TAG/UNTAG commands.
UNTAGGED	Refers to all but the previously selected (tagged) nodes; see the TAG/UNTAG commands.

READ

<table>
<tr><td rowspan="2">READ</td><td colspan="2">supno</td></tr>
<tr><td>SHOW-PROGRESS</td><td>supno</td></tr>
</table>

PURPOSE:

The command reads a first level superelement into Presel's database. That is, the Input Interface File of the superelement is read. The Input Interface File must have the following name, also see Section 2.3:

prefixTsupno.FEM

Note: **When using the SESAM Manager to control your analysis the prefix will normally be void.**

Note: **The prefix is given when starting Presel. This means that if the Input Interface File has a prefix then this prefix must be given at start-up. Also note that the Input Interface File names of all first level superelements must have the same prefix.**

PARAMETERS:

supno	Number (identification) of a first level superelement.
SHOW-PROGRESS	This option causes feedback to be given on how many cards (records) are read. The feedback looks like this: 400 CARDS READ 800 CARDS READ etc. By default no such feedback is given. (In previous versions of Presel such feedback was by default given.)

ROTATE

ROTATE	X-AXIS	degrees
	Y-AXIS	
	Z-AXIS	

PURPOSE:

The command rotates the display about the coordinate axes of the current superelement.

The SET GRAPHICS EYE-DIRECTION and the interactive rotations provide alternative ways of rotating the display. See the ‘direct access buttons’ described in Section 3.1 about interactive rotation.

PARAMETERS:

X-AXIS	Rotate about the X-axis.
Y-AXIS	Rotate about the Y-axis.
Z-AXIS	Rotate about the Z-axis.
degrees	Angle in degrees.

SET

<table>
<tr><td rowspan="11">SET</td><td>ANGLE-TOLERANCE</td><td colspan="3">angtol</td></tr>
<tr><td>COMMAND-INPUT-FILE</td><td colspan="3">comfilnam</td></tr>
<tr><td>COORDINATE-TOLERANCE</td><td colspan="3">cotol</td></tr>
<tr><td>GRAPHICS</td><td colspan="3">...</td></tr>
<tr><td rowspan="2">JOURNALLING</td><td>GRAPHICS</td><td rowspan="2">...</td><td>ON</td></tr>
<tr><td>PRINT</td><td>OFF</td></tr>
<tr><td rowspan="2">MODEL-FILE</td><td rowspan="2">prefix</td><td rowspan="2">filnam</td><td>NEW</td></tr>
<tr><td>OLD</td></tr>
<tr><td>PLOT</td><td colspan="3">...</td></tr>
<tr><td>PRINT</td><td colspan="3">...</td></tr>
<tr><td>UNIT-VECTOR-TOLERANCE</td><td colspan="3">uvtol</td></tr>
</table>

PURPOSE:

The command sets different parameters for controlling the execution of other commands.

PARAMETERS:

ANGLE-TOLERANCE	Specify the angle tolerance used for determining whether an angle is 90 degrees or not.
angtol	The angle tolerance in degrees, the default value is 0.001.
COMMAND-INPUT-FILE	Specify a command input file. The file is opened and is ready for reading using the # command. The command input file *cannot* have the same name as the Presel command log file. Note that specifying and reading a command input file is normally more conveniently done through Manager.
comfilnam	Name of the command input file. The file extension must be JNL and shall not be given.
COORDINATE-TOLERANCE	Specify the coordinate tolerance used for deciding whether two points (nodes) have the same geometrical position and for deciding whether a node lies in a plane or on a line.
cotol	The coordinate tolerance given in the same unit as the coordinates. The default value is 0.1.
GRAPHICS	Set various parameters controlling the display and plot. The command is described in detail in the following.

JOURNALLING	Switch on or off journalling of the selected set of commands, i.e. either GRAPHICS or PRINT commands. Journalling is off when the program is started, even if journalling was switched on in a previous session with the same model file.
MODEL-FILE	Close the current model file and open another without exiting and re-entering the program. When accessing Presel through Manager you should not use this command.
prefix	The prefix of the new model file.
filnam	The file name of the new model file.
NEW OLD	NEW means that the model file will be created (starting a new session from scratch), OLD means that it exists already (continuing an earlier session).
PLOT	Set various parameters controlling the plot. The command is described in detail in the following.
PRINT	Set various parameters controlling the print. The command is described in detail in the following.
UNIT-VECTOR-TOLERANCE	Specify a unit vector tolerance used for deciding whether two vectors span a plane and whether a matrix is orthonormal.
uvtol	The unit vector tolerance (without unit) has default value 0.001.

SET GRAPHICS

<table>
<tr><td rowspan="33">...</td><td rowspan="33">GRAPHICS</td><td colspan="5">ALTERNATIVE-SCREEN-DEVICE</td></tr>
<tr><td colspan="5">AUTO</td></tr>
<tr><td colspan="5">BASIC-ELEMENT-MODE</td></tr>
<tr><td rowspan="2">CHARACTER-TYPE</td><td colspan="4">SOFTWARE</td></tr>
<tr><td colspan="4">HARDWARE</td></tr>
<tr><td rowspan="6">COLOUR</td><td colspan="2">BOUNDARY-CONDITION</td><td rowspan="6">colour</td><td rowspan="6">tone</td></tr>
<tr><td colspan="2">ELEMENT-LINES</td></tr>
<tr><td colspan="2">INCLUDED-SUPERELEM</td></tr>
<tr><td colspan="2">NODE-NUMBER</td></tr>
<tr><td colspan="2">NODE-SYMBOL</td></tr>
<tr><td colspan="2">SUPER-NODES</td></tr>
<tr><td>DEVICE</td><td colspan="4">device-name</td></tr>
<tr><td>EYE-DIRECTION</td><td>eyex</td><td>eyey</td><td colspan="2">eyez</td></tr>
<tr><td rowspan="2">HIDDEN</td><td colspan="4">ON</td></tr>
<tr><td colspan="4">OFF</td></tr>
<tr><td rowspan="2">INPUT</td><td colspan="4">ON</td></tr>
<tr><td colspan="4">OFF</td></tr>
<tr><td rowspan="2">NODE-SELECTION</td><td colspan="4">ON</td></tr>
<tr><td colspan="4">OFF</td></tr>
<tr><td>PLOT-FILE</td><td>prefix</td><td colspan="3">filnam</td></tr>
<tr><td rowspan="4">PRESENTATION</td><td colspan="3" rowspan="2">COLOUR-SUPERELEMENTS</td><td>ON</td></tr>
<tr><td>OFF</td></tr>
<tr><td colspan="3" rowspan="2">FILLED-ELEMENT</td><td>ON</td></tr>
<tr><td>OFF</td></tr>
<tr><td rowspan="2">SCALING-AUTOMATIC</td><td colspan="4">ON</td></tr>
<tr><td colspan="4">OFF</td></tr>
<tr><td>SHRINK-FACTOR</td><td colspan="4">shrinkfac</td></tr>
<tr><td rowspan="6">SIZE-SYMBOLS</td><td colspan="3">BOUNDARY-CONDITION-SYMBOLS</td><td rowspan="6">size</td></tr>
<tr><td colspan="3">LOAD-NUMBERS</td></tr>
<tr><td colspan="3">NODE-NUMBERS</td></tr>
<tr><td colspan="3">NODE-SYMBOLS</td></tr>
<tr><td colspan="3">ONE-NODED-ELEMENT-SYMBOLS</td></tr>
<tr><td colspan="3">ORIGIN-SYMBOL</td></tr>
</table>

PURPOSE:

The command sets different parameters for controlling the DISPLAY, PLOT and LABEL commands.

PARAMETERS:

ALTERNATIVE-SCREEN-DEVICE	This option is presently not in use.
AUTO	This option has presently no function in Presel.
BASIC-ELEMENT-MODE	This option is presently not in use.
CHARACTER-TYPE	Choose how characters are displayed. Device generated (HARDWARE) characters are faster but there may be restrictions on the character size and orientation.
SOFTWARE	Drawn characters are used, this is the default choice.
HARDWARE	Device generated characters are used.
COLOUR	Change the colour used for displaying a certain item.
BOUNDARY-CONDITION	Change the colour of boundary conditions, default is medium blue.
ELEMENT-LINES	Change the colour of element lines, default is medium red.
INCLUDED-SUPERELEM	Change the colour of superelement being included, default is medium yellow.
NODE-NUMBER	Change the colour of node numbers, default is medium green.
NODE-SYMBOL	Change the colour of node symbols, default is medium yellow.
SUPER-NODES	Change the colour of supernodes, default is medium blue.
colour	Choose between the following colours: WHITE, GRAY, BLACK, BLUE, GREEN, ORANGE, RED, VIOLET and YELLOW.
tone	Choose between LIGHT, MEDIUM and DARK.
DEVICE	Choose the appropriate type of graphics device.
device-name	Type of graphics device. WINDOWS is the default choice in a Microsoft Windows environment. The command is currently of minor importance.
EYE-DIRECTION	Set the viewpoint for the display. Note that the default viewpoint is set through command line arguments, see Section 4.1.5, and these may in turn be set by Manager. You can also use the ROTATE command or the interactive rotations using the ‘direct access buttons’ described in Section 3.1.

eyex eyey eyez	X-, Y- and Z-coordinates of the viewpoint (the eye).
HIDDEN	Switch hidden display mode ON and OFF. The default is OFF.
INPUT	Switch between graphical user interface (ON) and line-mode (OFF). This command is currently irrelevant as the graphical user interface is the only option for interactive execution of the program.
NODE-SELECTION	Switch ON and OFF the possibility to select nodes graphically. The nodes will be displayed as small dots (yellow dots for free nodes and blue dots for supernodes). The default is ON.
PLOT-FILE	Set the name of the plot file. By default it is the same as the model and command log files. The extension of the plot file depends on the plot format; see the SET PLOT FORMAT command. This command has the same functionality as the SET PLOT FILE command. You may want to use the latter as it is more consistent with the other SET PLOT commands. Note that the command closes the current plot file (if such exists) enabling this to be sent to a laser printer without having to exit Presel.
prefix	Prefix of the plot file.
filnam	Name of the plot file.
PRESENTATION	Set the draw mode for elements and superelements.
COLOUR-SUPERELEMENTS	Switch colouring of superelements ON and OFF. Note that different occurrences of the same superelement number will have the same colour. The default is OFF.
FILLED-ELEMENT	Switch filling of elements (with a light blue colour) ON and OFF. The default is OFF.
SCALING-AUTOMATIC	Switch ON and OFF automatic scaling of the displayed superelement to fit the graphic display area. The default is ON.
SHRINK-FACTOR	Shrink the display of the basic elements.
shrinkfac	Shrink factor
SIZE-SYMBOLS	Specify the sizes of the symbols appearing on the displayed picture and the plot. The symbol sizes are given in mm.
BOUNDARY-CONDITION-SYMBOLS	Symbols for boundary conditions will be re-sized to the given value.
LOAD-NUMBERS	Load factors printed on top of the colour coded superelements by the DISPLAY LOAD FIRST-CONTRIBUTING-LOAD/

	NEXT-CONTRIBUTING-LOAD commands will be re-sized to the given value.
NODE-NUMBERS	Node number triplets will be re-sized to the given value.
NODE-SYMBOLS	Symbols for the nodes will be re-sized to the given value.
ONE-NODED-ELEMENT-SYMBOLS	Symbols for one node elements will be re-sized to the given value. These are the elements connected to only one node, i.e. SPRING-TO-GROUND and DAMPER-TO-GROUND.
ORIGIN-SYMBOLS	The symbol for the origin will be re-sized to the given value.
size	Symbol size in mm.

SET PLOT

<table>
<tr><td rowspan="16">...</td><td rowspan="16">PLOT</td><td rowspan="2">COLOUR</td><td colspan="2">ON</td></tr>
<tr><td colspan="2">OFF</td></tr>
<tr><td>FILE</td><td>prefix</td><td>filnam</td></tr>
<tr><td rowspan="7">FORMAT</td><td colspan="2">number</td></tr>
<tr><td colspan="2">CGM-BINARY</td></tr>
<tr><td colspan="2">HPGL-2</td></tr>
<tr><td colspan="2">HPGL-7550</td></tr>
<tr><td colspan="2">POSTSCRIPT</td></tr>
<tr><td colspan="2">SESAM-NEUTRAL</td></tr>
<tr><td colspan="2">WINDOWS-PRINTER</td></tr>
<tr><td>ORIENTATION</td><td colspan="2">PORTRAIT</td></tr>
<tr><td rowspan="5">PAGE-SIZE</td><td colspan="2">A1</td></tr>
<tr><td colspan="2">A2</td></tr>
<tr><td colspan="2">A3</td></tr>
<tr><td colspan="2">A4</td></tr>
<tr><td colspan="2">A5</td></tr>
</table>

PURPOSE:

The command sets parameters for plotting. The settings must be done prior to giving the PLOT command.

PARAMETERS:

COLOUR	Switch ON or OFF colours. The default is OFF. Colours are supported by the formats PostScript, HPGL-2 and CGM. Give this command after the SET PLOT FILE/FORMAT commands and prior to the PLOT command.
FILE	Set the name of the plot file. By default it is the same as the model and command log files. The extension of the plot file depends on the plot format; see the SET PLOT FORMAT command. Note that the command closes the current plot file (if such exists) enabling this to be sent to a laser printer without having to exit Presel.
prefix	Prefix of the plot file.
filnam	Name of the plot file.
FORMAT	Set the plot format.

number	The plotter number may alternatively be given. However, you will normally not know this.
CGM-BINARY	The ISO 8632-3 Computer Graphics Metafile (CGM) plot format (binary encoding). File extension is .CGM. This format is convenient for including plots in reports; see more information on this in Section 4.1.4.
HPGL-2	A Hewlett Packard plot format. File extension is .HPG2.
HPGL-7550	A Hewlett Packard plot format. File extension is .HP70.
POSTSCRIPT	The PostScript plot format. File extension is .PS.
SESAM-NEUTRAL	A plot format of the SESAM system. This is the default format on most computers. File extension is .PLO. The SESAM auxiliary program Pltcnv is required to reproduce the plot on paper.
WINDOWS-PRINTER	A plot file will *not* be created rather the plot will be sent directly to an on-line printer.
ORIENTATION	Set the page orientation. This command is presently redundant as portrait is the only choice.
PORTRAIT	Portrait orientation.
PAGE-SIZE	Set the plot page size. All sizes are not available for all plot formats. For SESAM-NEUTRAL this setting is irrelevant as the page size is set within the PLOT command. Give this command after the SET PLOT FILE/FORMAT commands and prior to the PLOT command.
A1 A2 A3 A4 A5	European standard page sizes (paper formats). See explanation for the PLOT command. A4 is the default choice.

NOTES:

For PostScript and HPGL-2 the size specification in the PLOT command is dummy. It will not change the plot size. The specification has not been removed to ensure compatibility with old input files.

For SESAM-NEUTRAL format the SET PLOT PAGE-SIZE has no effect as the size specification within the PLOT command is used.

SET PRINT

<table>
<tr><td rowspan="12">...</td><td rowspan="12">PRINT</td><td rowspan="2">DESTINATION</td><td colspan="2">FILE</td></tr>
<tr><td colspan="2">SCREEN</td></tr>
<tr><td rowspan="2">FILE</td><td colspan="2">LINEPRINTER</td></tr>
<tr><td>NAME</td><td>filnam</td></tr>
<tr><td rowspan="3">FORMAT</td><td colspan="2">E</td></tr>
<tr><td colspan="2">F</td></tr>
<tr><td colspan="2">G</td></tr>
<tr><td rowspan="2">PAGESIZE</td><td>FILE</td><td rowspan="2">nlines</td></tr>
<tr><td>SCREEN</td></tr>
<tr><td rowspan="3">TABLE</td><td rowspan="2">NODE-BOUNDARY-TABLE</td><td>DIGITS</td></tr>
<tr><td>TEXT</td></tr>
<tr><td>SUPER-ELEMENT-HIERARCHY</td><td>width</td></tr>
</table>

PURPOSE:

The command sets different parameters controlling the execution of the PRINT command.

PARAMETERS:

DESTINATION	Destination of print is set to FILE or SCREEN. This setting overrules the default destination which varies depending on what to print. However, the commands PRINT ALL and PRINT supno will always send their output to file (because of the anticipated large amount of output).
FILE	Decide the name of the print file. The default name is the same as the model (and command log) file name. The file extension is .LIS.
LINEPRINTER	This option has presently no function.
NAME filnam	Set the print file name to filnam.
FORMAT	Select between E, F and G FORTRAN format for printing real numbers. F is the default selection. Very large real numbers cannot be printed in F format; the user may in such cases select E or G.
PAGESIZE	Decide number of lines printed for each 'page'. The table heading is repeated for each page.

FILE	Decide number of lines printed for each ‘page’ on file.
SCREEN	Decide number of lines printed for each ‘page’ on screen. After each page give CONTINUE to print the next page and END to quit printing. Note that the default command at this stage is CONTINUE. Therefore, giving the command ‘;’ (semicolon) — which accepts all subsequent defaults — will print all pages.
nlines	Number of lines printed for each ‘page’.
TABLE	Control appearance of selected tables.
NODE-BOUNDARY-TABLE	Switch between TEXT (which is default) and DIGITS representation of the boundary condition codes. See the PRINT NODE BOUNDARY command.
SUPER-ELEMENT-HIERARCHY	Set the number of character positions used for each level in the table showing the superelement hierarchy which is printed by the PRINT SUPER-ELEMENT-HIERARCHY command. See the example print in Figure 3.3.
width	Number of character positions. The default value is 16. For a superelement hierarchy with many levels (e.g. 6 or more) a smaller value may allow the table to be produced correctly. A value less than 8 will normally not be meaningful.

TAG

TAG	select-nodes

PURPOSE:

The command tags (in effect: puts into a set) some or all nodes for the purpose of referring to these nodes (the TAGGED), or to all other nodes (the UNTAGGED), in subsequent commands (e.g. for defining boundary conditions). Initially, no nodes are tagged.

Tagged nodes are untagged by the UNTAG command.

PARAMETERS:

select-nodes Select nodes; see Section 5.1.

TASK

TASK	ASSEMBLY
	SUB-MODELLING

PURPOSE:

The command switches between the modes ASSEMBLY which is the normal way of using Presel as explained in this manual and SUB-MODELLING which is for sub-modelling as explained in the Submod User Manual.

As it is normally more convenient to access Submod directly rather than through Presel the TASK command has little relevance.

TRANSFORMATION

TRANSFORMATION	trano	spx	spy	spz	gpx	gpy	gpz

PURPOSE:

The command defines a rotated coordinate system. A transformation matrix is established that transforms coordinates from a rotated coordinate system to the global coordinate system. The purpose of the command is:

- For specifying a fixation or a prescribed displacement in a rotated (transformed) coordinate system. See the BOUNDARY command.
- For specifying nodal loads in a rotated (transformed) coordinate system. See the LOAD NODE command.

The transformation matrix is defined by giving the global coordinates of a second point (SP) and a guiding point (GP). The x-axis of the transformed coordinate system, X_T, goes from the origin to SP. The transformed z-axis, Z_T, is perpendicular to X_T so that GP lies in the X_T-Z_T plane on the positive Z_T side. Y_T is perpendicular to X_T and Z_T. See Figure 5.10.

PARAMETERS:

trano	Transformation reference number.
spx spy spz	Second point global coordinates.
gpx gpy gpz	Guiding point global coordinates.

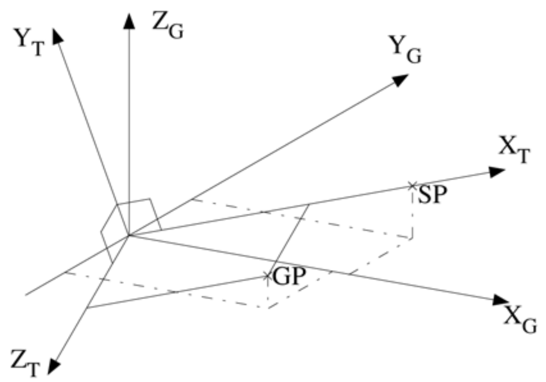


Figure 5.10 Definition of a transformed coordinate system

UNTAG

UNTAG	select-nodes

PURPOSE:

The command untags (in effect: removes from a set) some or all nodes for the purpose of referring to these nodes (the UNTAGGED), or to all other nodes (the TAGGED), in subsequent commands (e.g. for defining boundary conditions). Initially, all nodes are untagged.

Nodes are tagged by the TAG command.

PARAMETERS:

select-nodes Select nodes; see Section 5.1.

WRITE

WRITE	supno

PURPOSE:

The command writes Input Interface Files for the given superelement supno and all superelements in the hierarchy below supno except for the first level superelements (which exist before the execution of Presel).

See Section 2.3 for information on the Input Interface Files.

ZOOM

<table>
<tr><td rowspan="3">ZOOM</td><td colspan="2">FRAME</td></tr>
<tr><td>IN</td><td rowspan="2">...</td></tr>
<tr><td>OUT</td></tr>
</table>

PURPOSE:

The command zooms in or out on the displayed picture.

The zoom buttons of the 'direct access button area' have the same effect and are quicker in use; see Section 3.1. However, the ZOOM command differs from the 'direct access buttons' in that they are for command logging and input purposes. Logging is subject to use of the SET JOURNALLING GRAPHICS command.

The FRAME option makes the displayed model fill the graphic area.

For the IN and OUT options use the mouse (left mouse button) to give the zoom area. You may either:

- press and hold while dragging to the opposite corner of a rectangle and then release, or
- click first one corner of a rectangle and then click the diagonally opposite corner.

The actual zoom area is the smallest square containing the rectangle.

ZOOM IN will magnify the part of the picture that is inside the zoom area.

ZOOM OUT will fit the picture into the zoom area.

# #

<table>
<tr><td rowspan="2">#</td><td>ncomnd</td></tr>
<tr><td>ALL</td></tr>
</table>

PURPOSE:

The command reads commands from the command input file. The command input file is opened by the command SET COMMAND-INPUT-FILE. The command input file may be a command log file from a previous run or a file prepared by a text editor.

The program will execute commands from the command input file until:

- an end-of-file is detected,
- a # is found on the file,
- ncomnd number of commands have been read, or
- an erroneous command sequence is found.

PARAMETERS:

ncomnd	Number of commands to be read from the command input file.
ALL	All commands are read from the command input file.

APPENDIX A TUTORIAL EXAMPLES

In order to perform the tutorial examples of Chapter 3 some superelements created by Prefem are required. The inputs for these are presented in the following.

A 1 The Tutorials in Assembling Superelements and Combining Loads

In the tutorial example of Section 3.2.2 and Section 3.3.2 the two first level superelements 5 and 6 are assembled into the second (and top) level superelement 7. The Prefem inputs required for creating superelements 5 and 6 are provided below. Having created these two superelements you will be able to perform the Presel tutorials.

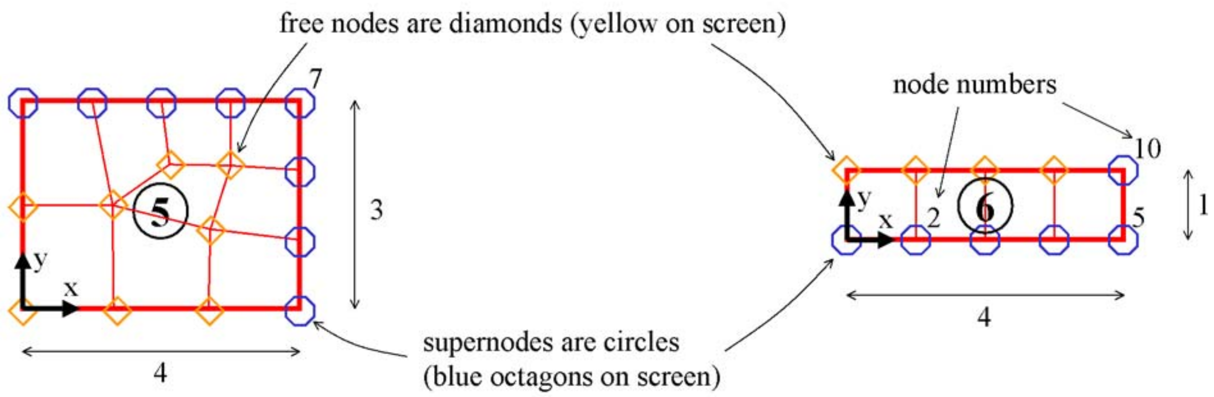


Figure A.1 The two first level superelements 5 and 6 created by Prefem

A 1.1 Superelement 5

```
%===============================================================================
%
% Prefem input for creating superelement number 5.
```

```
% Semicolons (;) are used to accept default values.
%
%==============================================================================
% --- First create geometry:
 GENERATE SURFACE A 1 2 1 4 1 2 1 2 END
          CARTESIAN 0 0 0
          4 0 0 END 0 3 0 END
% --- Adjust number of elements to be created along lines:
 SET NUMBEROF-ELEMENTS ( AI11 AJ21 ) 3
 ..
% --- Then select 4 node shell element to be used:
 SET ELEMENT-TYPE SURFACE ALL-SURFACES-INCLUDED SHELL-4NODES
 ..
% --- Define supernodes on two lines:
 PROPERTY BOUNDARY-CONDITION ( AI12 AJ21 )
          SUPERNODE SUPERNODE SUPERNODE SUPERNODE SUPERNODE SUPERNODE
          GLOBAL
 ..
% --- Define thickness:
 PROPERTY THICKNESS ALL-SURFACES-INCLUDED .01
 ..
% --- Define and connect material:
 PROPERTY MATERIAL STEEL ELASTIC ;
 ..
 CONNECT MATERIAL STEEL ALL-SURFACES-INCLUDED END
% --- Define line load:
 PROPERTY LOAD 8 LINE-LOAD AJ11 GLOBAL 1.5 0 0 ;
 ;
% --- Create mesh
 MESH ALL
% --- The model is now complete. Exit Prefem.
%==============================================================================
```

A 1.2 Superelement 6

```
%==============================================================================
%
% Prefem input for creating superelement number 6.
% Semicolons (;) are used to accept default values.
%
%==============================================================================
% --- First create geometry:
 GENERATE SURFACE A 1 2 1 4 1 2 1 1 END
          CARTESIAN 0 0 0
          4 0 0 END 0 1 0 END
% --- Then select 4 node shell element to be used:
 SET ELEMENT-TYPE SURFACE ALL-SURFACES-INCLUDED SHELL-4NODES
 ..
% --- Define supernodes on two lines:
 PROPERTY BOUNDARY-CONDITION ( AI11 AJ21 )
          SUPERNODE SUPERNODE SUPERNODE SUPERNODE SUPERNODE SUPERNODE
          GLOBAL
```

```
 ..
% --- Define thickness:
 PROPERTY THICKNESS ALL-SURFACES-INCLUDED .01
 ..
% --- Define and connect material:
 PROPERTY MATERIAL STEEL ELASTIC ;
 ..
 CONNECT MATERIAL STEEL ALL-SURFACES-INCLUDED END
% --- Define line loads:
 PROPERTY LOAD 3 LINE-LOAD AJ11 GLOBAL 1.5 0 0 ;
 ;
 PROPERTY LOAD 4 LINE-LOAD AI12 GLOBAL 0 -3.0 0 ;
 ;
% --- Create mesh
 MESH ALL
% --- The model is now complete. Exit Prefem.
%==============================================================================
```

A 2 The Tutorial in Assembling Loads

In the tutorial example of Section 3.4.2 and Section 3.4.3 the five first level superelements 1 through 5 are assembled to form the top level superelement 100. The Prefem inputs required for creating these first level superelements are provided below. Having created these superelements you will be able to perform the Presel tutorials.

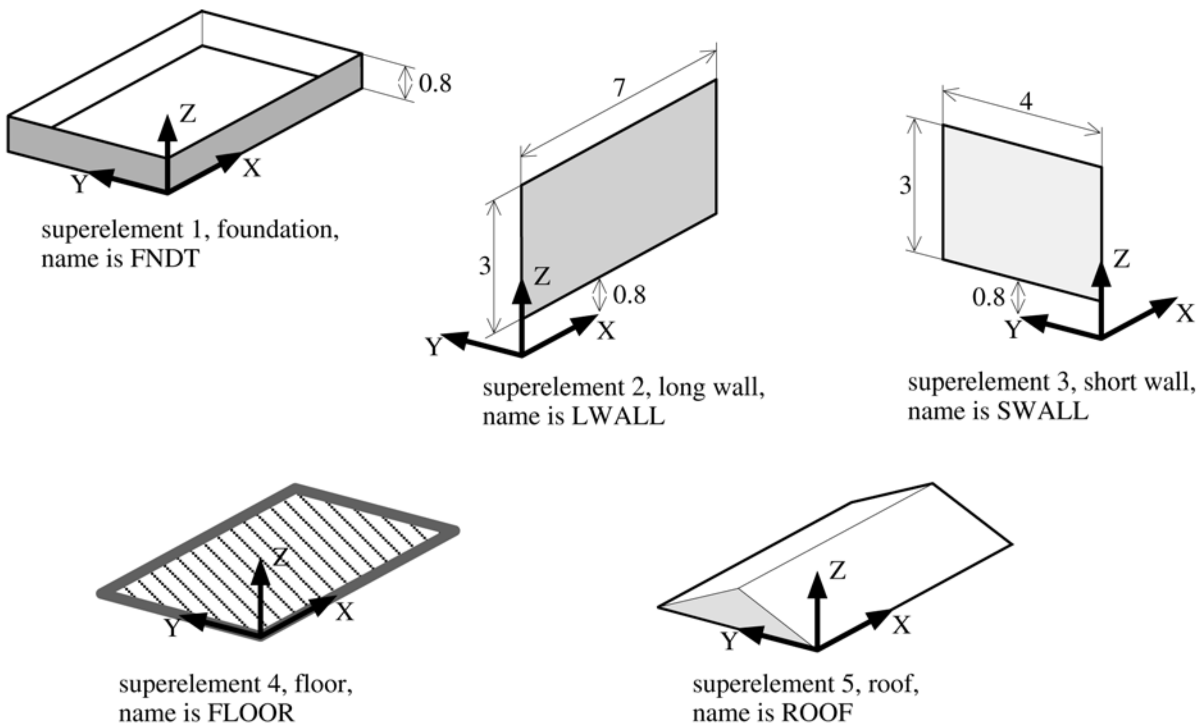


Figure A.2 The first level superelements 1, 2, 3, 4 and 5 created by Prefem

A 2.1 Superelement 1

```
%===============================================================================
%
% Prefem input for creating superelement number 1, the foundation.
%
%===============================================================================
% --- First create geometry:
 GENERATE SURFACE A 1 2 1 4 1 2 1 2 1 2 1 1
          CARTESIAN 0 0 0
          7 0 0 END 0 4 0 END 0 0 0.8 END
 DELETE GEOMETRY AU*
 ..
% --- Then select 8 node shell element to be used:
 SET ELEMENT-TYPE SURFACE ALL-SURFACES-INCLUDED SHELL-8NODES
 ..
% --- Define fixations and supernodes:
 PROPERTY BOUNDARY-CONDITION
          ( AJ&&1 AI&&1 )
          FIX FIX FIX FIX FIX FIX
          GLOBAL
          ( AJ&&2 AI&&2 )
          SUPERNODE SUPERNODE SUPERNODE SUPERNODE SUPERNODE SUPERNODE
          GLOBAL
 ..
% --- Define thickness:
 PROPERTY THICKNESS ALL-SURFACES-INCLUDED 0.1
 ..
% --- Define and connect material:
 PROPERTY MATERIAL CONCR ELASTIC 0.3E11 0.25 2500 0 0
 ..
 CONNECT MATERIAL CONCR ALL-SURFACES-INCLUDED END
% --- Define line load:
 PROPERTY LOAD 1 GRAVITY GLOBAL FLEXIBLE-PART-CONTRIBUTION 0 0 -9.81
                 END
 ..
% --- Create mesh
 MESH ALL
% --- The model is now complete. Exit Prefem.
%===============================================================================
```

A 2.2 Superelement 2

```
%===============================================================================
%
% Prefem input for creating superelement number 2, the long wall.
%
%===============================================================================
% --- First create geometry:
 GENERATE SURFACE A 1 2 1 4 1 2 1 2 END
          CARTESIAN 0 0 0.8
          7 0 0 END 0 0 3 END
```

```
% --- Then select 8 node shell element to be used:
 SET ELEMENT-TYPE SURFACE ALL-SURFACES-INCLUDED SHELL-8NODES
 ..
% --- Define supernodes:
 PROPERTY BOUNDARY-CONDITION ALL-LINES-INCLUDED
          SUPERNODE SUPERNODE SUPERNODE SUPERNODE SUPERNODE SUPERNODE
          GLOBAL
 ..
% --- Define thickness:
 PROPERTY THICKNESS ALL-SURFACES-INCLUDED 0.05
 ..
% --- Define and connect material:
 PROPERTY MATERIAL CONCR ELASTIC 0.3E11 0.25 2500 0 0
 ..
 CONNECT MATERIAL CONCR ALL-SURFACES-INCLUDED END
% --- Define loads:
 PROPERTY LOAD 1 GRAVITY GLOBAL FLEXIBLE-PART-CONTRIBUTION 0 0 -9.81
                 END
          LOAD 2 NORMAL-PRESSURE ALL-SURFACES-INCLUDED 1500 END MIDDLE-SURFACE
                 END
 ..
% --- Create mesh
 MESH ALL
% --- The model is now complete. Exit Prefem.
%===============================================================================
```

A 2.3 Superelement 3

```
%===============================================================================
%
% Prefem input for creating superelement number 3, the short wall.
%
%===============================================================================
% --- First create geometry:
 GENERATE SURFACE A 1 2 1 2 1 2 1 2 END
          CARTESIAN 0 0 0.8
          0 4 0 END 0 0 3 END
% --- Then select 8 node shell element to be used:
 SET ELEMENT-TYPE SURFACE ALL-SURFACES-INCLUDED SHELL-8NODES
 ..
% --- Define supernodes:
 PROPERTY BOUNDARY-CONDITION ALL-LINES-INCLUDED
          SUPERNODE SUPERNODE SUPERNODE SUPERNODE SUPERNODE SUPERNODE
          GLOBAL
 ..
% --- Define thickness:
 PROPERTY THICKNESS ALL-SURFACES-INCLUDED 0.04
 ..
% --- Define and connect material:
 PROPERTY MATERIAL CONCR ELASTIC 0.3E11 0.25 2500 0 0
 ..
 CONNECT MATERIAL CONCR ALL-SURFACES-INCLUDED END
```

```
% --- Define loads:
 PROPERTY LOAD 1 GRAVITY GLOBAL FLEXIBLE-PART-CONTRIBUTION 0 0 -9.81
                 END
          LOAD 2 NORMAL-PRESSURE ALL-SURFACES-INCLUDED -1500 END MIDDLE-SURFACE
                 END
 ..
% --- Create mesh
 MESH ALL
% --- The model is now complete. Exit Prefem.
%==============================================================================
```

A 2.4 Superelement 4

```
%==============================================================================
%
% Prefem input for creating superelement number 4, the floor.
%
%==============================================================================
% --- First create geometry:
 GENERATE SURFACE A 1 2 1 4 1 2 1 2 END
          CARTESIAN 0 0 0
          7 0 0 END 0 4 0 END
% --- Then select 8 node shell element to be used:
 SET ELEMENT-TYPE SURFACE ALL-SURFACES-INCLUDED SHELL-8NODES
 ..
% --- Define supernodes:
 PROPERTY BOUNDARY-CONDITION ALL-LINES-INCLUDED
          SUPERNODE SUPERNODE SUPERNODE SUPERNODE SUPERNODE SUPERNODE
          GLOBAL
 ..
% --- Define thickness:
 PROPERTY THICKNESS ALL-SURFACES-INCLUDED 0.05
 ..
% --- Define and connect material:
 PROPERTY MATERIAL CONCR ELASTIC 0.3E11 0.25 2500 0 0
 ..
 CONNECT MATERIAL CONCR ALL-SURFACES-INCLUDED END
% --- Define loads:
 PROPERTY LOAD 1 GRAVITY GLOBAL FLEXIBLE-PART-CONTRIBUTION 0 0 -9.81
                 END
          LOAD 2 NORMAL-PRESSURE ALL-SURFACES-INCLUDED 3000 END MIDDLE-SURFACE
                 END
 ..
% --- Create mesh
 MESH ALL
% --- The model is now complete. Exit Prefem.
%==============================================================================
```

A 2.5 Superelement 5

```
%==============================================================================
%
```

```
% Prefem input for creating superelement number 5, the roof.
%
%=============================================================================
% --- First create geometry:
 GENERATE SURFACE A 1 2 1 4 1 2 1 2 1 2 1 2
          CARTESIAN 0 0 0
          7 0 0 END 0 4 0 END 0 2 0.9 END
 DELETE GEOMETRY ( AU* AS* AT121 AI122 AJ112 AJ212 )
 ..
 CHANGE LINE AK121 AP121 AP112 2
             AK221 AP221 AP212 2
 ..
 DELETE GEOMETRY ( AP122 AP222 )
 ..
 DEFINE SURFACE AS111 AK111 AK121 AJ111
                AS211 AK211 AK221 AJ211
                AT121 AI121 AK121 AI112 AK221
 ..
% --- Then select 8 node shell element to be used:
 SET ELEMENT-TYPE SURFACE ALL-SURFACES-INCLUDED SHELL-8NODES
 ..
% --- Define supernodes:
 PROPERTY BOUNDARY-CONDITION ( AJ&&1 AI&&1 )
          SUPERNODE SUPERNODE SUPERNODE SUPERNODE SUPERNODE SUPERNODE
          GLOBAL
 ..
% --- Define thickness:
 PROPERTY THICKNESS ALL-SURFACES-INCLUDED 0.03
 ..
% --- Define and connect material:
 PROPERTY MATERIAL CONCR ELASTIC 0.3E11 0.25 2500 0 0
 ..
 CONNECT MATERIAL CONCR ALL-SURFACES-INCLUDED END
% --- Define loads:
 PROPERTY LOAD 1 GRAVITY GLOBAL FLEXIBLE-PART-CONTRIBUTION 0 0 -9.81
                 END
          LOAD 2 COMPONENT-PRESSURE AT* GLOBAL 0 0 -2500 END MIDDLE-SURFACE
                 END
 ..
% --- Create mesh
 MESH ALL
% --- The model is now complete. Exit Prefem.
%=============================================================================
```

APPENDIX B THEORY

B 1 Mathematical Foundation for Superelement Technique

The superelement technique is based on the principle of static condensation (reduction) of the equation system of part models (superelements). This involves eliminating the internal (free) nodes (or d.o.f.s) from the equation system thereby achieving a reduced equation system containing only the supernodes (or super d.o.f.s) of the part model. The mathematical foundation for the superelement technique is explained in the following by comparing it with a direct analysis (i.e. not using the superelement technique). The superelement technique is only applicable for linear static analysis.

B 1.1 Direct Analysis

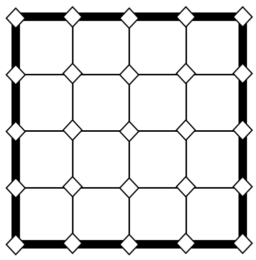


Figure B.1 Direct Analysis — a Single Superelement

Figure B.1 shows a very simple plate model. The equation of equilibrium for the single superelement, which constitute the whole model, is:

$$\mathbf{K}\mathbf{r} = \mathbf{R} \qquad \text{(B.1)}$$

where **K** is the stiffness matrix, **r** is the displacement (d.o.f.) vector and **R** is the load vector. Solving this equation system in one operation yields the displacements for the whole model:

$$\mathbf{r} = \mathbf{K}^{-1}\mathbf{R} \qquad \text{(B.2)}$$

B 1.2 Superelement Analysis

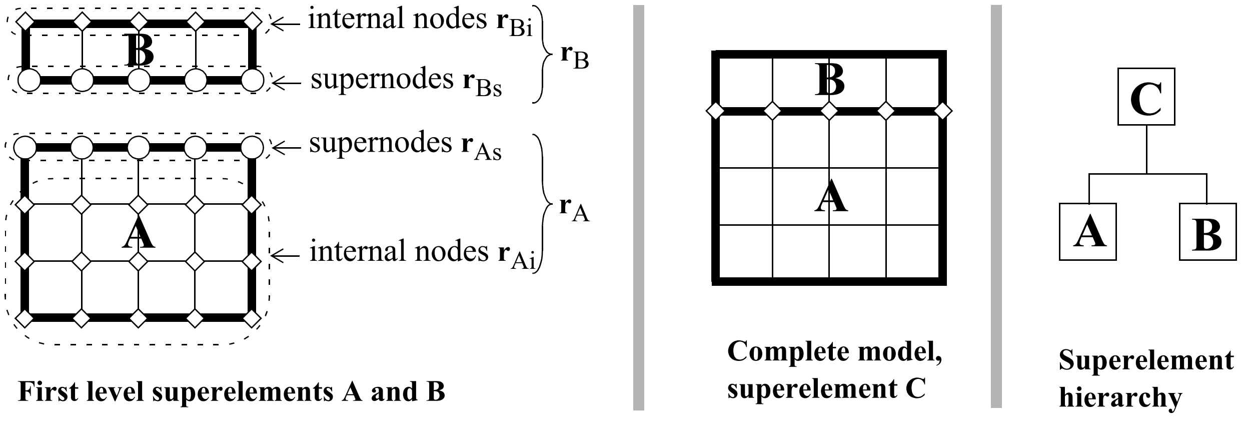


Figure B.2 Superelement Analysis

Figure B.2 shows the same model as in the previous section but now it is divided into two superelements (part models) A and B which assembled constitute the complete model C.

Stiffness matrix, displacement vector and load vector for each superelement are established:

$\mathbf{K}_A$, $\mathbf{r}_A$, $\mathbf{R}_A$ for superelement A

$\mathbf{K}_B$, $\mathbf{r}_B$, $\mathbf{R}_B$ for superelement B

We now want to perform a *reduction* to eliminate the internal d.o.f.s for both superelements ($\mathbf{r}_{Ai}$ and $\mathbf{r}_{Bi}$).

Let the following equation system be the equation of equilibrium of one of superelements A and B (subscripts A/B are skipped):

$$\mathbf{K}\mathbf{r} = \mathbf{R} \tag{B.3}$$

This can be written in a partitioned form by sorting the d.o.f.s of $\mathbf{r}$ so that all internal d.o.f.s come first, 'i' denotes internal d.o.f.s and 's' denotes super d.o.f.s:

$$\begin{bmatrix} \mathbf{K}_{ii} & \mathbf{K}_{is} \\ \mathbf{K}_{is}^T & \mathbf{K}_{ss} \end{bmatrix} \begin{bmatrix} \mathbf{r}_i \\ \mathbf{r}_s \end{bmatrix} = \begin{bmatrix} \mathbf{R}_i \\ \mathbf{R}_s \end{bmatrix} \tag{B.4}$$

Equation (B.4) may be written as two separate equations:

$$\mathbf{K}_{ii}\mathbf{r}_i + \mathbf{K}_{is}\mathbf{r}_s = \mathbf{R}_i \tag{B.5}$$

$$\mathbf{K}_{is}^T\mathbf{r}_i + \mathbf{K}_{ss}\mathbf{r}_s = \mathbf{R}_s \tag{B.6}$$

Equation (B.5) may be solved with respect to $\mathbf{r}_i$:

$$\mathbf{r}_i = -\mathbf{K}_{ii}^{-1}\mathbf{K}_{is}\mathbf{r}_s + \mathbf{K}_{ii}^{-1}\mathbf{R}_i \tag{B.7}$$

This inserted in Equation (B.6) yields:

$$(\mathbf{K}_{ss} - \mathbf{K}_{is}^T\mathbf{K}_{ii}^{-1}\mathbf{K}_{is})\mathbf{r}_s = \mathbf{R}_s - \mathbf{K}_{is}^T\mathbf{K}_{ii}^{-1}\mathbf{R}_i \tag{B.8}$$

or:

$$\mathbf{k}\mathbf{r}_s = \mathbf{F} \tag{B.9}$$

where:

$$\mathbf{k} = \mathbf{K}_{ss} - \mathbf{K}_{is}^T\mathbf{K}_{ii}^{-1}\mathbf{K}_{is} \tag{B.10}$$

$$\mathbf{F} = \mathbf{R}_s - \mathbf{K}_{is}^T\mathbf{K}_{ii}^{-1}\mathbf{R}_i \tag{B.11}$$

When this operation is performed for both superelements A and B their matrices are reduced as follows:

$$\mathbf{K}_A \rightarrow \mathbf{k}_A$$

$$\mathbf{r}_A \rightarrow \mathbf{r}_{As}$$

$$\mathbf{R}_A \rightarrow \mathbf{F}_A$$

$$\mathbf{K}_B \rightarrow \mathbf{k}_B$$

$$\mathbf{r}_B \rightarrow \mathbf{r}_{Bs}$$

$$\mathbf{R}_B \rightarrow \mathbf{F}_B$$

When superelements A and B are coupled it follows that:

$$\mathbf{r}_{As} = \mathbf{r}_{Bs} = \mathbf{r}_s \tag{B.12}$$

What this means is that both superelements A and B contribute with stiffness and loads to the supernodes. The reduced stiffness and loads may consequently be added:

$$(\mathbf{k}_A + \mathbf{k}_B)\mathbf{r}_s = (\mathbf{F}_A + \mathbf{F}_B) \tag{B.13}$$

This is the equation of equilibrium for the complete model expressed in the d.o.f.s of the top level superelement. *Solving* this equation yields $\mathbf{r}_s$.

When $\mathbf{r}_s$ is known the internal displacements of A and B, $\mathbf{r}_{Ai}$ and $\mathbf{r}_{Bi}$ respectively, are found by inserting $\mathbf{r}_s$ in Equation (B.7) (the matrices of this equation are saved during reduction of each superelement). This operation is termed *retracking*:

$$\mathbf{r}_{Ai} = -\mathbf{K}_{Aii}^{-1}\mathbf{K}_{Ais}\mathbf{r}_s + \mathbf{K}_{Aii}^{-1}\mathbf{R}_{Ai} \tag{B.14}$$

$$\mathbf{r}_{Bi} = -\mathbf{K}_{Bii}^{-1}\mathbf{K}_{Bis}\mathbf{r}_s + \mathbf{K}_{Bii}^{-1}\mathbf{R}_{Bi} \tag{B.15}$$

The terms *reduction*, *solving* and *retracking* are highlighted above as these are three major phases of a superelement analysis (sequential processes automatically executed by the analysis program Sestra).

B 1.3 Rotating and Mirroring a Superelement

In the example of Section B 1.2 none of the superelements are rotated or mirrored. However, if a superelement *is* rotated (as is the case for the second inclusion of superelement 6 in the example of Section 3.2.2) then the reduced matrices must be transformed before being added to the stiffness and load matrices of the superelement assembly.

When translating, rotating and mirroring a superelement to include it in a superelement assembly a transformation matrix is established; see the ‘INCLUDE supno PRINT-T-MATRIX’ command. The three by three cosine matrix part of this three by four transformation matrix constitute the required transformation for the reduced matrices. If **T** is the name of this three by three cosine matrix the d.o.f. vector of the reduced superelement after the transformation is:

$$\mathbf{r}_{Ts} = \mathbf{T}^T\mathbf{r}_s \qquad \text{(B.16)}$$

The stiffness and load matrices are transformed as follows (note that for the orthogonal three by three transformation matrix **T** the inverse matrix is equal to the transformed matrix):

$$\mathbf{k}_T = \mathbf{T}^T\mathbf{k}\mathbf{T} \qquad \text{(B.17)}$$

$$\mathbf{F}_T = \mathbf{T}^T\mathbf{F} \qquad \text{(B.18)}$$

It follows from the last equation that the loads of a superelement are rotated and mirrored along with the superelement when this is being included in a superelement assembly. Translations of the superelement has no effect on the loads.

This is exemplified in Section 3.3.2 where load 3 on superelement 6, see Figure 3.8, is rotated (and multiplied by 2) when combined into global load 2 of top level superelement 7; see note 6 of Figure 3.9.

Also note that to allow the stiffness, **k**, and load, **F**, matrices to be multiplied by a three by three transformation matrix these matrices must for all nodes include either all three translational d.o.f.s, or all three rotational d.o.f.s, or all six d.o.f.s. In other words, to rotate or mirror a superelement only these three alternative selections of super d.o.f.s for a node are allowed. Any other selection of the six d.o.f.s of a node to be super will only allow the superelement to be translated when being included in an assembly.

For more information on the superelement technique see the Sestra documentation.